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THE EFFECTS OF FILL PATTERNS ON GRAPHICAL INTERPRETATION AND DECISION MAKING

THESIS

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The views expressed in this thesis are those of the authors and do not reflect the official policy or position of the Department of Defense or U.S. Government.

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THESIS

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Preface

The purpose of this research was to compare graphs which contained chartjunk, or fill patterns, to graphs which did not use fill patterns to see if there were differences in interpretation or decision making.

An experiment was conducted at the Air Force Institute of Technology (AFIT) using vertical bar graphs with and without fill patterns. Participants in the experiment were asked to decide if three fictitious companies should be approved for a loan based upon either a graphical or tabular presentation of financial data. They were then asked to determine the appropriate loan amount given specific decision rules. The experiment used a 3 X 4 factorial design in which varying degrees of fill patterns and trends were manipulated between cells.

The choice of fill pattern did not appear to affect decision making overall; however, there was a statistically significant difference between graphs with no fill pattern and those with a heavy fill pattern for one of the fictitious companies. The trend variable did appear to affect decisions at a statistically significant level.

We would like to thank the many instructors and students within the Professional Continuing Education (PCE) department for allowing us to use their classes during both the pretests and actual experiment.

We would also like to thank our thesis advisors, Major David Christensen and Mr. Richard Antolini for their help in keeping us on track and for providing significant insights into the world of research and experimental design.

Finally we would like to thank our families for their steadfast support and encouragement during our time at AFIT.

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Abstract

This thesis investigated whether individuals interpreted graphics with fill patterns differently from graphics which did not use fill patterns and whether their decisions were affected. A literature review indicated that there was a lack of current research concerning the use of fill patterns within graphics and whether those fill patterns affect decision making. A timed 3 X 4 factorial experiment, in which subjects were asked to approve, and then decide upon an appropriate loan amount for three fictitious companies, was conducted. Within the experiment, trend and mode of presentation (fill pattern intensity) were manipulated between the various cells. One hundred eighty-two Professional Continuing Educations students attending classes at the Air Force Institute of Technology participated in the experiment. Using an F-statistic, it was determined that the mode of presentation did not affect decision making although there was a statistically significant difference between graphs using no fill pattern and those containing a heavy fill pattern for one of the companies. Additionally, the trend component appears to affect decision making even after normalizing the numerical data. There was weak evidence that gender affects decisions based upon graphical presentations. Specifically, female subjects appeared to approve larger loan amounts than did male subjects.

THE EFFECTS OF FILL PATTERNS ON GRAPHICAL INTERPRETATION AND DECISION MAKING

I. Introduction

General Purpose

Graphs provide powerful tools for analyzing data and for communicating quantitative information. The computer graphics revolution, which began in the 1960's and has intensified during the past several years, stimulated the invention of graphical methods. This revolution has caused a recent surge of interest in computer graphics. In 1984, the computer graphics industry was estimated to be growing at an annual rate of 60 to 70 percent a year (DeSanctis, 1984:463). One estimate suggested that from 1987 to 1992, the total presentation graphics industry was expected to triple in size (Miller, 1992:114). The National Computer Graphics Association estimates that the business graphics software market will reach $26 billion by 1993, of which half is for presentation graphics products (Caron, 1991:95). In a survey cited by Jarvenpaa and Dickson, they claim that 96 percent of graphics users forecasted that business graphics usage would "increase at least to a moderate extent" and 40 percent forecasted "a great extent of increased usage" (Jarvenpaa and Dickson, 1985:1). Finally, Edward Tufte is quoted as suggesting that there are "between 900 billion and two trillion statistical graphics printed each year" (Patton, 1992:29).

Rapidly declining hardware costs plus, flexible, easy-to-use software, and office work stations account for these trends.

In the Department of Defense (DoD), as well as the private sector, managers must be able to disseminate large volumes of information quickly and accurately. Because of this need, computer graphics have become a vital tool used by managers to communicate ideas and disseminate information. According to proponents, graphics can improve managerial productivity (Hwang and Wu, 1990:12; Taylor and Anderson, 1986:126). However, previous research has indicated that the method of graphical presentation can affect a manager's ability to interpret the data (Cleveland and McGill, 1985; Cochran, Albrecht, and Green, 1989; Kern, 1991; Larkin, 1990; MacKay and Villarreal, 1987).

Currently, there exists over 100 software packages available for developing charts and graphs (Caron, 1993:93). Many of these software packages have a wide range of capabilities that allow users to make graphs quicker and easier. In addition, almost all software packages have features that allow interior decoration of graphics, thus, permitting the users to enhance their graphs and charts. In fact, most software packages such as Quattro Pro and Lotus 1-2-3 automatically default to provide interior decoration especially within area and bar charts (Quattro Pro User's Guide, 1992:405; Lotus User's Guide, 1991:121-132). For the purposes of this thesis, the interior decoration of graphs and charts will be referred to as "chartjunk" and defined as non-data ink or redundant data ink (Tufte, 1983:117). This chartjunk can be used for a variety of purposes such as making graphs appear more scientific or precise, enlivening the display, or giving the designer an

opportunity to exercise his or her artistic skills (Tufte, 1983:117). Although sales of graphical presentation software continue to increase, little attention has been paid to the use of chartjunk and its effect on graphical presentations. An example of chartjunk similar to that described by Tufte can be found in Figure 1. Within this graph it can be noted that there is excessive scaling, grid lines, multiple fill patterns with varying degrees of optical vibration, excessive labeling, using all capital letters, and so on (Tufte, 198:120).

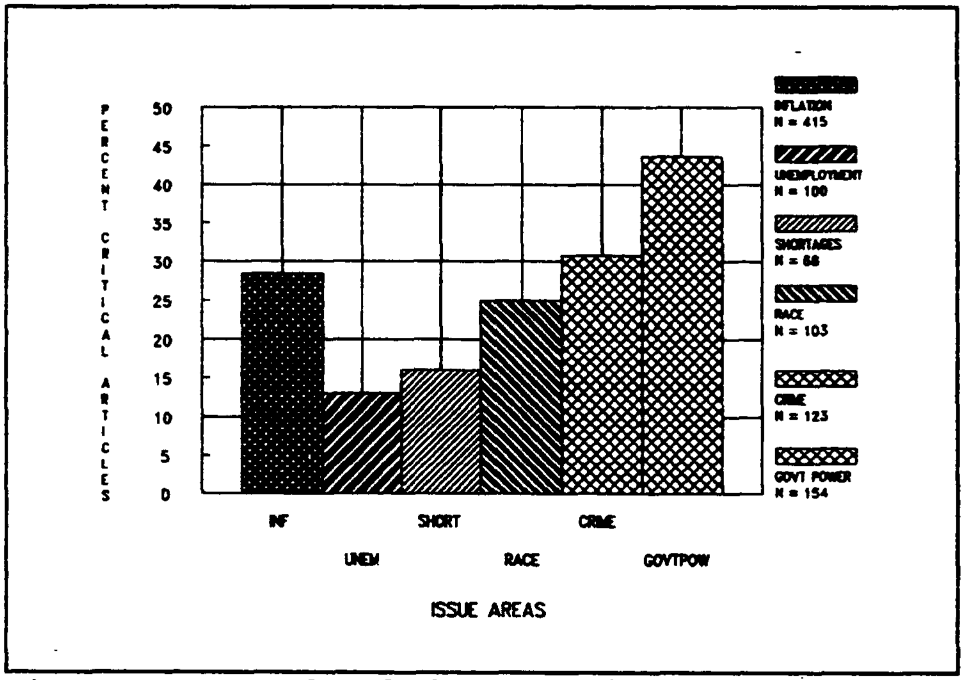


Figure 1. Example of Chartjunk (Tufte, 1983: 120).

Two primary concerns arise due to the presence of chartjunk. First, is it possible to convince a decision maker to support a project, purchase, or proposal based upon the degree to which a chart or graph is decorated? The opposite of this concern is also a legitimate issue. Specifically, is it possible for an otherwise sound project, purchase, or proposal to be rejected because the chart or graph is not decorated?

Second, if the interior decoration (chartjunk) of a chart or graph does not affect decision making ability, are those who present graphs wasting time and resources by trying to enliven the graphs? It is apparent that charts decorated with chartjunk are pervasive at all levels of business and government. For example, the Economic Report of the President Transmitted to the Congress February 1990 contains several bar graphs, all of which use fill patterns (Economic Report of the President, 1990:34, 35, 118, 128, 146, 149, 169). In fact, many firms and DoD agencies construct charts and graphs which contain various forms of chartjunk such as logos, icons, and fill patterns. Additionally, Tufte expressed concern over the use of chartjunk, to include fill patterns, especially those which appear to vibrate (cross-hatching fill patterns) stating they "cloud the flow of information" (Tufte, 1983:108). He has referred to chartjunk as "content free decoration" and goes on to say that "clutter and confusion are failures of design, not attributes of information" (Patton, 1992:29, 31).

Table 1 provides a list and description of several types of chartjunk commonly found in graphics today (Tufte, 1983:107-122; Cleveland, 1985:24, 37, 100-101).

Specific Problem

The main purpose of this research is to determine to what extent the manipulation of the presentation mode (i.e., graphical with chartjunk versus tabular) and trend (i.e. increasing, decreasing, or no significant change) components of numerical information affect the decision making process. Furthermore, does the perception or interpretation of the degree of intensity of the presentation mode and

trend of numerical information affect data perception, interpretation and decision making?

Table 1. Typical Forms of Chartjunk (Tufte, 1983:107-121).

Chartjunk Type	Description/Explanation
Fill patterns	Interior decoration of bar, pie, or area charts.
Grid lines	Horizontal or vertical lines drawn through the data region of the graph.
False, or fake perspectives	Graphs of two-dimensional data drawn as three-dimensional.
Excessive scaling or tick marks	Showing more numerical markers than there are data points within the graph.
Excessive labeling, titles, or legends	Repeated or excessive labels, titles, or legends especially when located in the data region.

In this study, chartjunk consisting of fill patterns within horizontal or vertical bar charts will be examined. Fill patterns are defined as non-data ink used to define the interior of the bar within a bar chart. For example, Figure 2 contains a bar chart without any chartjunk or fill pattern. Figure 3, which contains the same underlying numerical data as Figure 2, utilizes a cross-hatch fill pattern. Fill patterns can take many forms. Some of the more common fill patterns consist of filling the bar with a solid block of ink, cross-hatch, cross-stitch, dots, plus signs, bricks, and cobblestones. Some software packages even allow the designer of the graph to manipulate how intense

the cross-hatching or cross-stitching design will be within the bar graph (Harvard Graphics User's Manual, 1990). Figure 4 shows a light cross-hatch pattern. Two additional fill patterns found in many computer graphics software programs are depicted in Figure 5, (stitch) and Figure 6, (line) (Quattro Pro User's Guide, 1992:408, 409).

For the purposes of this study, the presentation mode will be limited to vertical bar graphs using either no fill pattern, varying intensities of cross-hatch fill patterns, and tabular data. The reasoning behind this is to present a single, uniform instrument to compare and contrast the various effects of chartjunk. Previous research has shown that by changing the graphical method, the perception of the data presented by the graph is changed (Cleveland, 1985:229-294; Cochran, Albrecht, and Green, 1989). The effects of graphics on perception will be discussed in greater detail in the literature review.

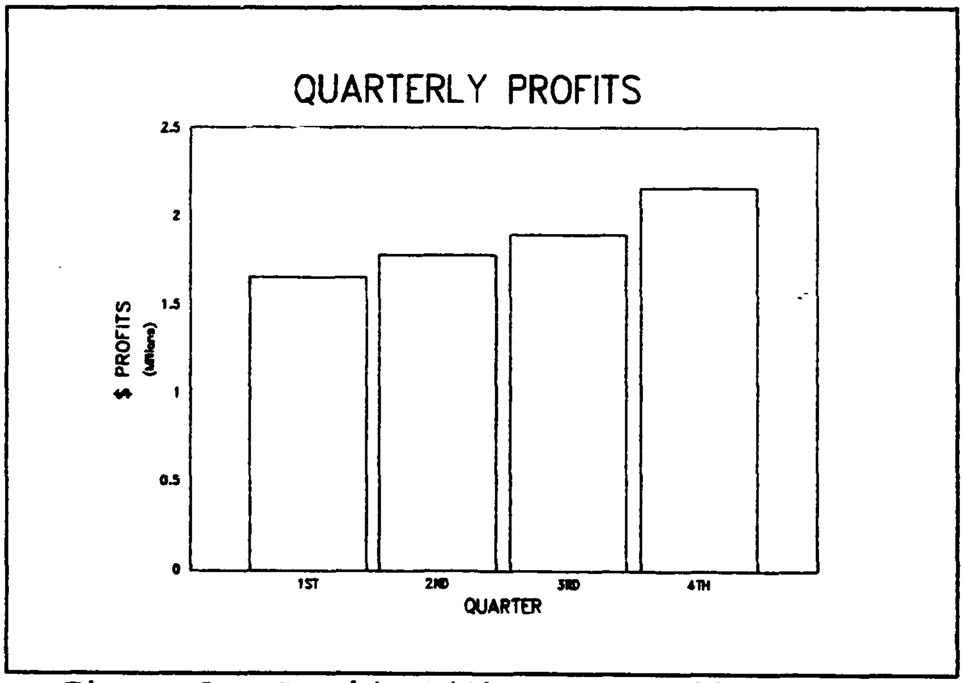


Figure 2. Graphic Without any Fill Pattern.

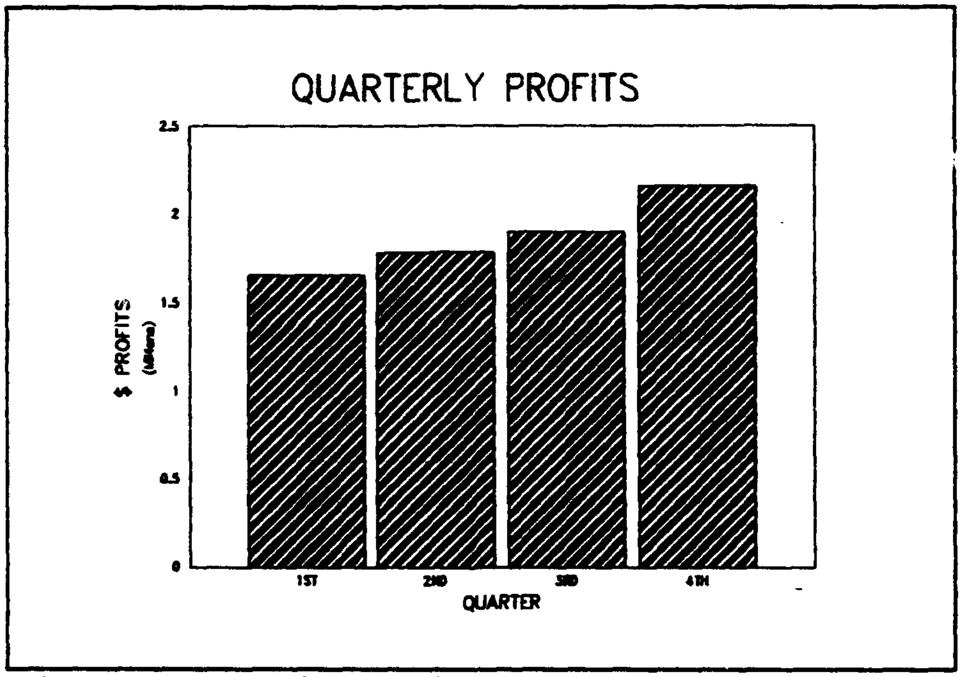


Figure 3. Graphic With Cross-hatch Fill Pattern.

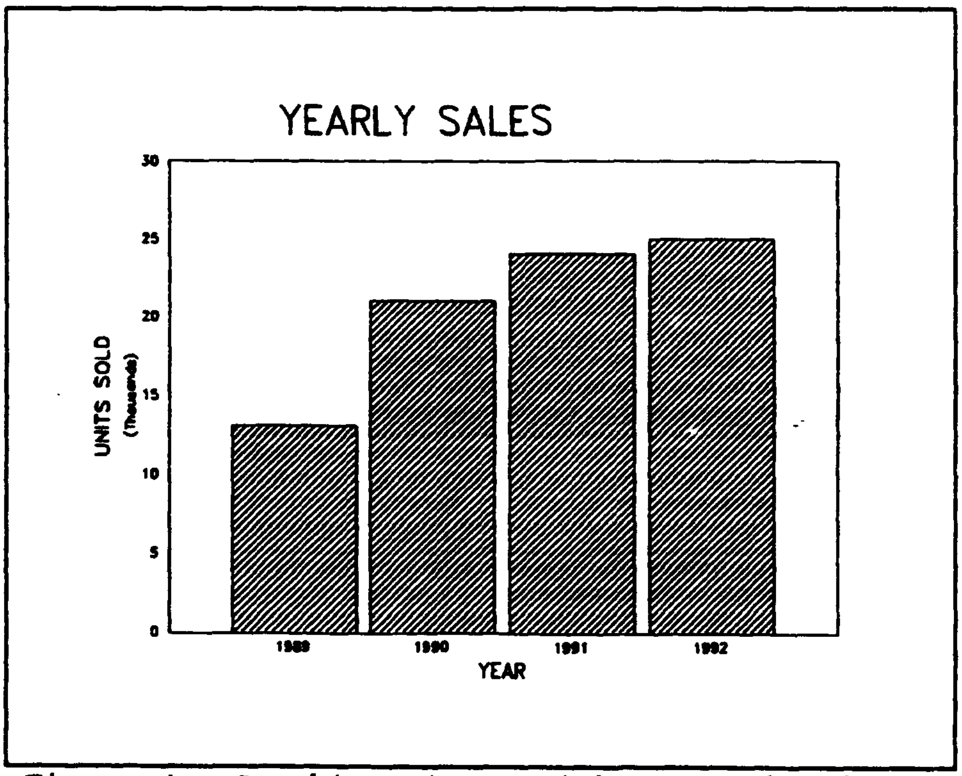


Figure 4. Graphic Using a Light Cross-hatch Fill Pattern.

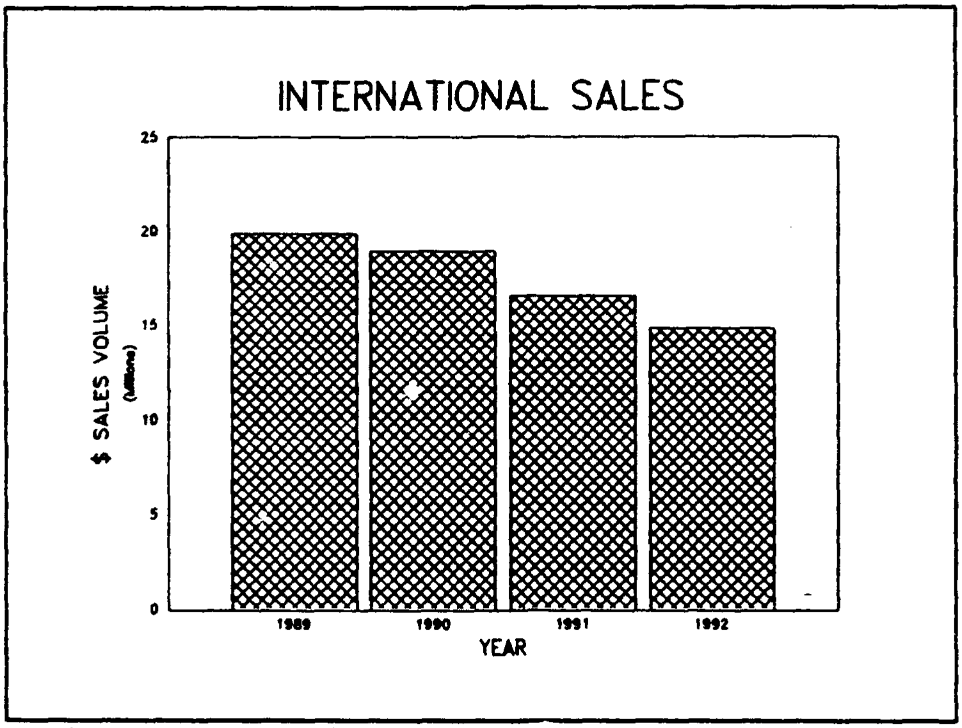


Figure 5. Graphic Using a Stitch Fill Pattern (Quattro Pro User's Guide, 1992:408).

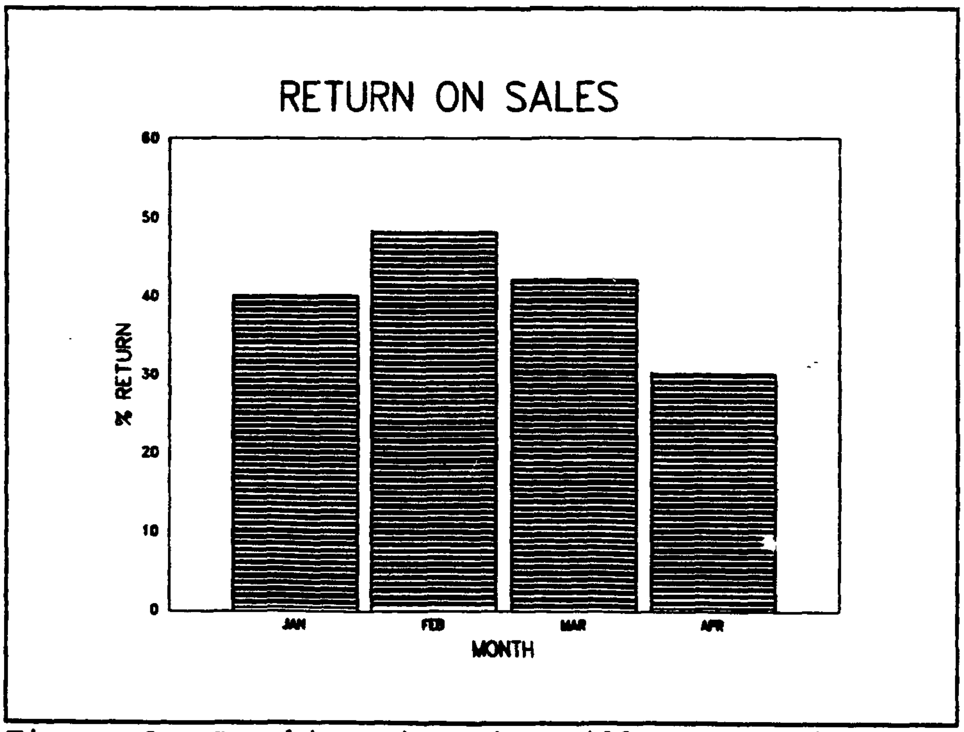


Figure 6. Graphic Using Line Fill Pattern (Quattro User's Guide, 1992:408, 409).

For the purposes of this research, optical art or designs that interact with the physiological tremor of the eye to produce the appearance of vibration or movement (the moiré effect) will be used to depict data. Vibrating chartjunk uses the moiré effect to catch the eye of the viewer as depicted in Figure 7. The effect extends beyond the ink of the design to the whole page. This moiré vibration, which is the most common form of chartjunk, can cloud the flow of information (Tufte, 1983:108). The moiré effect is captured best by using varying intensities of cross-hatch fill patterns.

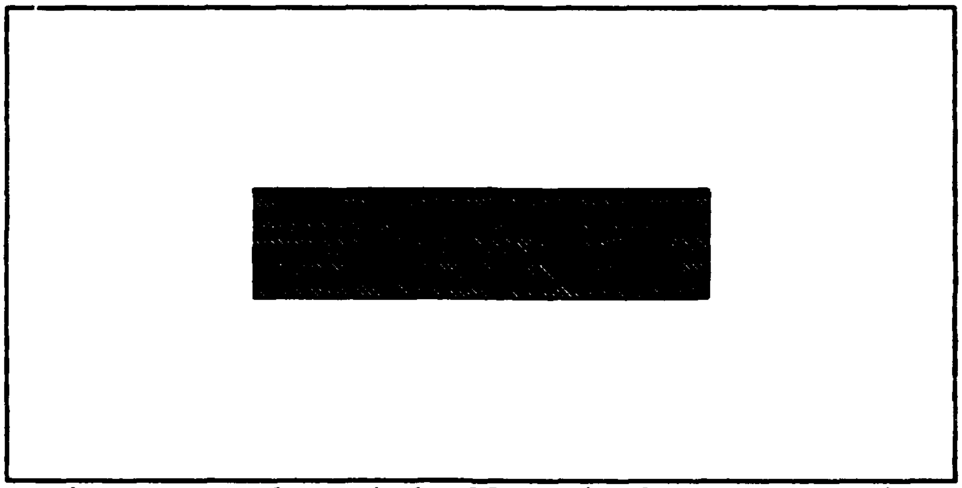


Figure 7. The Moiré Effect (Tufte, 1983:108).

To limit the variability in this study, other graphical presentation variables such as color, data distortion, and subject relevancy will be eliminated. A timed 3 X 4 factorial experiment, in which subjects were asked to approve, and then decide upon an appropriate loan amount for three fictitious companies was conducted in order to measure the effect of the mode of presentation (fill patterns or tabular data) and trend on decision making. Graphs contained either no fill pattern, or were manipulated to contain light, medium, or heavy

fill patterns. Using an F-statistic within the factorial design experiment made it possible to determine whether the mode of presentation made a difference in terms of the loan amount decision. Experimental graphs were developed to analyze the difference in interpretation and decision making concerning graphs with chartjunk versus graphs without chartjunk. All graphs were presented in black and white to eliminate the bias of color (Hoadley, 1990:121). Additionally, graphs in this study followed generally accepted high integrity graphics presentation rules (Carvalho and McMillan, 1992:55-60; Christensen and Larkin, 1990:130-142; Cleveland, 1985:100-101; Kern, 1991:42-44; Taylor and Anderson, 1986:127-135; Tufte, 1983). These accepted graphics rules will be discussed further in Chapter II.

The sample population consisted of Air Force Institute of Technology (AFIT) and Professional Continuing Education (PCE) students. This population sample consists almost exclusively of military and civilian members within the DoD. Because of the high standards and familiarity with graphical presentations, this sample population provides a unique representational blend of decision makers and managers from which to study. Additionally, virtually all those attending AFIT and PCE courses are mid- to upper-level managers. This fact makes this sample very representative of the more general target population of mid- to upper-level civilian and DoD managers.

Hypotheses

The primary null hypotheses (Ho) for this research are as follows:

1. Manipulation of the mode of presentation and trend of data do not affect decision making.

2. Manipulation of the mode of presentation and trend of data do not affect interpretation of the significance of a trend.

3. The manipulation of the mode of presentation and trend of data do not affect the perception of confidence in decision making.

4. The manipulation of the mode of presentation and trend of data do not affect the perception of risk in decision making.

5. Gender does not affect decision making.

The results of the hypotheses will be discussed further in Chapter V. The remainder of the thesis will demonstrate the reasoning behind the selection of these hypotheses, their testing, and an analysis of the results. Also, several investigative questions will be addressed to develop a better understanding of the effects of chartjunk on graphical presentations.

Investigative Questions

Along with the stated hypothesis, several investigative questions will be researched throughout the study. Primarily, these investigative questions are focused toward the effect of chartjunk on interpretation of data and determining what standards, if any, exist to help in the proper use of chartjunk. The following is a list of investigative questions that will be addressed throughout the thesis:

1. What standards have been developed to ensure the integrity of graphical presentations including those which contain chartjunk?

2. Is there empirical evidence to support the proper use of graphs to include those containing chartjunk?

3. Are there any demographic trends related to chartjunk and graphical interpretation?

4. What preferences exist concerning various forms of chartjunk versus graphical presentations which do not contain chartjunk?

Limitations

There are several limitations concerning the scope of this research. The first limitation centers around the decision to conduct the experiment using only vertical bar charts and tabular data displays. Limiting the research to these types of charts was based on their susceptibility to being manipulated by use of fill patterns. Additionally, bar charts, both horizontal and vertical, are among the most popular of graphical methods used. Another limitation is the decision to limit fill patterns to various types and degrees of cross-hatching. Although many other types of fill patterns exist, cross-hatch fill patterns can be manipulated to display varying degrees of intensity. By varying the degree of intensity of the fill pattern, more precise measurements of the overall affect of fill patterns can be determined. Nonetheless, other fill patterns may not have the same effect on perception.

The strict classroom environment used in the experiment may limit the realism and external validity of the experiment. However, strict controls concerning the experiment, which are only available in a laboratory or classroom environment, will enhance the internal validity of the experiment. The strict use of time limits for interpreting the graphs and making decisions concerning them were deemed appropriate because of the limited time to accomplish tasks or make decisions in most managerial positions. Finally, the choice of full-time and PCE AFIT students may limit the scope of this research. AFIT students

represent mid-level managers who will have varying levels of experience in preparing or reviewing graphics presentations. Because these students are already managers and because of their experience with graphics, they were deemed an acceptable sample source for a more general category of both mid-level and upper-level managers. However, the fact that all AFIT students plus others sampled are associated with the DoD may have some confounding effects on the results of the experiment. Any additional limitations concerning the specific methodology used to conduct this research/experiment are discussed in Chapter III.

Synopsis

Chapter II, Literature Review, will summarize the research and studies performed on graphical presentations pertinent to this thesis. Within Chapter II, investigative questions one, two, and four will be answered. Chapter III, Methodology, will explain the research design, methods of chartjunk selection, population sample, experimental development, analysis, and statistical tests used. Chapter IV, Findings and Analysis, will include comments on the administration of the experiment, the results of the experiment, and the interpretation of those results. Within Chapter IV, all hypotheses and investigative question three will be answered. Chapter V, Summary, will discuss the conclusions of the tested hypotheses and point out recommendations for future areas of research.

II. Literature Review

The purpose of this chapter is to report on the review of various research articles and publications pertaining to graphical presentation criteria, experiments, and chartjunk. The chapter consists of five sections as follows: (1) Introduction, (2) Criteria for High Integrity Graphics, (3) Results of Selected Graphical Experiments, (4) Fill Patterns and Chartjunk, (5) Conclusion.

Section one gives a brief introduction to graphics uses and addresses concerns over whether graphs can be misleading. Section two gives the primary criteria believed necessary to ensure the underlying data contained in a graph are displayed in such a manner that they do not mislead the viewer of the graph. Section three briefly reports on the results of several experiments conducted at AFIT and elsewhere in which specific graphical criteria were manipulated to see if the viewer's perceptions and/or interpretations of the graph could be altered. Section four reports on the use of fill patterns within graphics. Additionally, viewpoints and theories concerning whether fill patterns serve any purpose in terms of data interpretation or enhancement are discussed. Section five gives a brief conclusion or overview of the important findings within this chapter.

Introduction

Graphical presentations of data are becoming more and more common. One author, DeSanctis, suggests that current anecdotal research indicates the reasons for including graphics are to permit rapid

presentation of data and to help decision makers assimilate the data quickly. Graphics allow presentation of extremely large masses of data in a compact, easy-to-read format (DeSanctis, 1984:467). Mintzberg, like DeSanctis, suggests that managers activities are characterized by brevity (Mintzberg, 1989:301-304). Specifically, Mintzberg noted with regard to the activities of chief executive officers:

> Half of the observed activities were completed in less than nine minutes, and only one-tenth took more than an hour. In effect, the managers were seldom able or willing to spend much time on any one issue in any one session. (Mintzberg, 1973:33)

Mintzberg goes on to suggest that as one goes further down the chain of command, activities become even more brief (Mintzberg, 1973:34). Additionally, Taylor and Anderson claim that graphics can "increase productivity and efficiency and in many cases have cut the cost of servicing clients" (Taylor and Anderson, 1986:126). Finally, Jarvenpaa and Dickson suggest graphs are most appropriate when used for: a quick summary of data, depicting trends over time, and comparing points and patterns of different variables (Jarvenpaa and Dickson, 1986:15).

Graphs appear in a myriad of applications. Both business and government realize that large amounts of data can be presented in a very concise manner if graphical presentations are used. Johnson and Rice contend that graphs can serve a two-fold function when presented in financial or annual reports.

> They can present comparative data in a manner that is easier to grasp than information in tabular form and they can serve as a medium for the expression of modern graphic design effects intended to impress the reader. (Johnson and Rice, 1990:50-51)

Furthermore, Cleveland and McGill claim that "graphs provide powerful tools both for analyzing scientific data and for communicating quantitative information" (Cleveland and McGill, 1985:828).

DeSanctis lists six specific graphical display applications covering a much wider range of graphing functions.

> 1. To facilitate the design of equipment and facilities. (design graphics).
>
> 2. To organize or schedule activities for planning and control purposes (scheduling graphics).
>
> 3. To communicate information formally that illustrates activities, accomplishments, or trends usually to a group of observers in a meeting (presentation graphics).
>
> 4. To analyze data as part of a statistical or financial analysis (analytical graphics).
>
> 5. To serve as a substitute for tables in standard data-processing reporting (report graphics).
>
> 6. To support the decision-making activities of high-level management (decision graphics). (DeSanctis, 1984:463-464)

Additionally, DeSanctis claims that graphical presentations in these areas may enhance the speed of decision making (DeSanctis, 1984:464).

From the previous review of literature, it is obvious that graphical displays can present data in many different ways. One underlying theme of graphical presentations is that they represent an exceptional method for comparing data. Several authors suggest that graphical presentations may be superior to tabular or other presentation formats when comparing trend data or making head-to-head comparisons of companies, operating divisions, products or processes (Christensen and Larkin, 1992:130; Johnson and Rice, 1990:50; Steinbart, 1986:60-61; Tan and Benbasat, 1990:431-435; Taylor and Anderson, 1986:126).

Graphical presentations can be helpful, but they can also be misleading. For example, a company could present a graphical display which distorted the underlying data for net income by not including zero on the Y axis (Christensen and Larkin, 1992:131-132; Taylor and Anderson, 1986:127). The effects of this distortion can be seen in Figure 8. A more ethical approach to displaying the company's net income would be to use a graphic which includes zero on the Y axis as shown in Figure 9. Investors could view the graphs differently and may come to different conclusions about the company's net income.

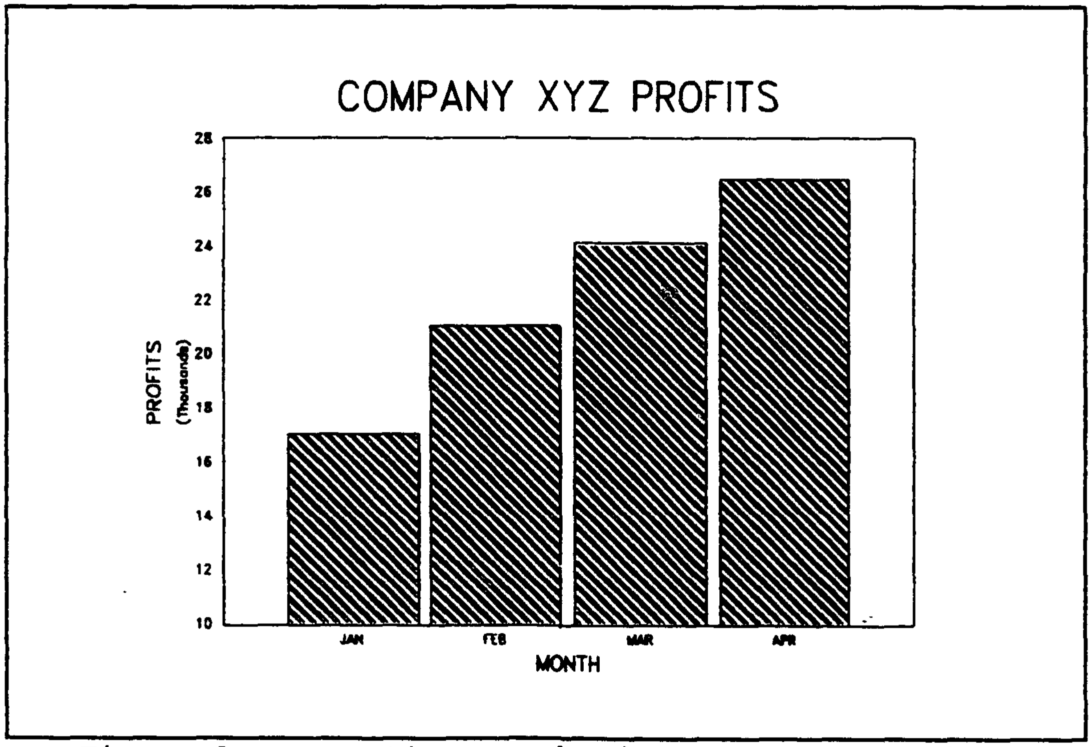


Figure 8. Deceptive Graph of XYZ Company Profits

Despite the potential for misleading graphs, many text books, such as introductory and intermediate statistics texts, do not spend very time explaining good graphing techniques. In fact, a convenience sample

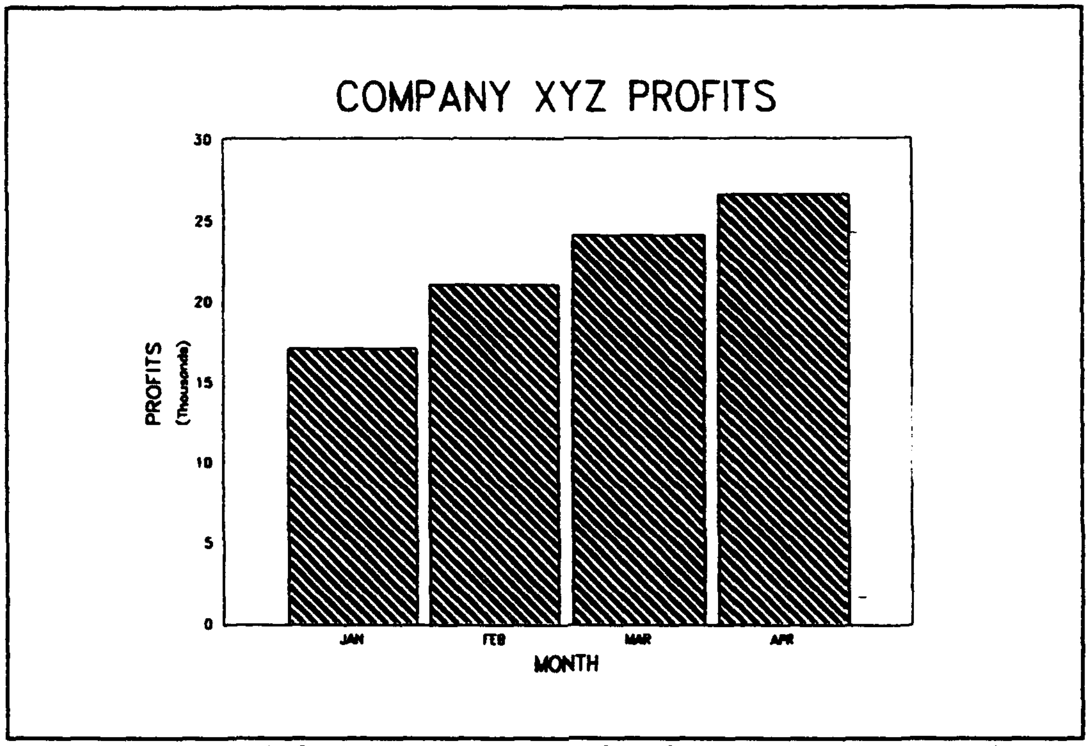


Figure 9. High Integrity Graph of XYZ Company Profits

of 17 introductory and intermediate statistics text books located in a mid-sized eastern university revealed that only six books devoted from one to four pages to misleading graphs and the remaining 11 books never discussed misleading graphs at all. All of these text books devoted various amounts of time explaining how and when to present graphs and charts but did not emphasize the potential for misleading readers of those graphs. Table 2, on the following page, lists the author, text title, and number of pages devoted to misleading graphs.

Even if the person viewing a graphical presentation receives some training on high integrity graphics, he or she can still be misled. One author, Steinbart, briefly summarizes the problem of good as compared to misleading graphs:

Table 2. Pages Dedicated to Proper Graphing Techniques.

Author	Title of Text	Pages Dedicated
Berenson & Levine	Basic Business Statistics (2nd Ed)	1
Daniel	Essentials of Business Statistics	0
Gitlow & Oppenheim	Stat City	0
Groebner & Shannon	Business Statistics a Decision-Making Approach	0
Hamburg	Statistical Analysis For Decision Making (5th Ed)	0
Johnson & Siskin	Elementary Business Statistics A First Course	3
Kazmier & Pohl	Basic Statistics For Business and Economics (2nd Ed)	0
McClave & Benson	A First Course in Business Statistics	4
McClave & Benson	Statistics For Business and Economics (5th Ed)	3
Meek & Turner	Statistical Analysis For Business Decisions	0
Mendenhall & Reinmuth	Statistics For Management and Economics (3rd Ed)	3
Newbold	Statistics For Business and Economics	0
Patchett	Statistical Methods For Managers and Administrators	2
Targett	Coping With Numbers	0
Webster	Applied Statistics For Business and Economics	0
Wonnacott & Wonnacott	Introductory Statistics For Business and Economics (3rd Ed)	0
Zuhwaylif	Applied Business Statistics (2nd Ed)	0

> When properly constructed, such graphs highlight and clarify significant trends in the data. Improperly constructed graphs, however, distort the trends and can mislead the reader. Even sophisticated users can be misled. (Steinbart, 1989:60)

Another problem associated with graphical displays is that the technology and availability of software have increased faster than the related training for graphical presentations. Jarvenpaa and Dickson claim that:

> With end-user graphics technology, the generation of graphs is shifting to persons lacking formal training in graphic design with the result that there is an increased opportunity for creating a wealth of poor quality and incompatible graphs. (Jarvenpaa and Dickson, 1985:2)

However, lack of training in graphical display methods is only part of the problem. It is also conceivable that companies would intentionally try to mislead potential investors. The next several paragraphs summarize the results of two surveys which show that certain companies may have tried to mislead the readers of their graphical presentations.

Steinbart conducted a survey of 319 Fortune 500 companies and found that 252 included graphs in their annual report. The following paragraphs highlight the results of Steinbart's research. Of the graphs containing sales, income, and dividend information, values were exaggerated by a magnitude of change of about 11 percent. Additionally, almost 26 percent of the graphs distorted the data by more than 10 percent and twenty-four graphs exaggerated trend data by 100 percent or more. There were 22 graphs which contained a discrepancy of more than

30 percent understatement. Finally, there were 26 annual reports which contained graphs that distorted the data in a manner which was favorable to the company (Steinbart, 1989:63, 65-69).

In a similar study, Johnson and Rice randomly selected 50 annual reports from Fortune 500 companies to see if any of the companies surveyed used misleading graphs in the presentation of financial data. Twenty-one of the annual reports contained misleading graphs. Of 423 graphs within the reports, 125, or 29.5 percent, were misleading. Some of the specific violations included the following: the scale on the dependent axis did not begin with zero, the inclusion of multiple scales, and the inclusion of complex or logarithmic scales (Johnson and Rice, 1990:52-54).

Within the same research effort, Johnson and Rice also found that the annual reports contained both good and misleading graphs. In fact, good and misleading graphs were found in 18 of the 21 annual reports which contained misleading graphs. This indicates that the companies which produced these annual reports may have understood how to present accurate graphs but chose to present misleading graphs (Johnson and Rice, 1990:59).

As a result of the previous discussion, a small but growing body of empirical research has developed to identify and test important facets of graphic presentations and their related interpretation. The rest of this chapter will review some of the research, criteria, and commentary concerning graphical displays.

Criteria For High Integrity Graphics

The discussion of high integrity graphics criteria is important to this research for two primary reasons. First, by using only graphs which adhere to high integrity graphics criteria, moderating variables and confounds will be limited while conducting any experiment. Second, style guides for high integrity graphics include direction on the use of chartjunk and fill patterns. The next several paragraphs will discuss criteria for high integrity graphics.

Concerns over potentially misleading graphs have led to the development of several high integrity graphical criteria. A good starting point for determining the degree of distortion in a graph is found in Tufte's Lie Factor model. Specifically, Tufte says, "the representation of numbers, as physically measured on the surface of the graph itself, should be directly proportional to the numerical quantities represented" (Tufte, 1983:56). The specific formula for the Lie Factor is found in Equation 1 below.

$$\textit{Lie Factor} = \frac{\textit{Size of Effect Shown within Graphic}}{\textit{Size of Effect within Data}} \qquad (1)$$

According to Tufte:

> If the lie factor is equal to one, then the graphic might be doing a reasonable job of accurately representing the underlying numbers. Lie factors greater than 1.05 or less than .95 indicate substantial distortion, far beyond minor discrepancies in plotting. (Tufte, 1983:57)

Several articles and books present very specific criteria for graphical presentations. Violation of any of the criteria may lead to misinterpretation of the underlying data which are portrayed in the graph. The Joint Committee on Standards for Graphic Presentation

initially set criteria for graphics as early as 1915 (Joint Committee on Standards For Graphic Presentation, 1915:790-798). More recently, additional researchers have added considerably to that original body of knowledge. Specifically, Taylor and Anderson correctly point out that graphs can be misleading even when the numerical data and the graph are equivalent (Taylor and Anderson, 1986:126-127). As a result, they suggest a series of criteria by which to evaluate or construct graphs.

Christensen and Larkin generally agree with the criteria suggested by Taylor and Anderson and presented additional guides. Specifically, Taylor and Anderson found points 1, 2, 4, and 8 on Table 3 important. Christensen and Larkin also found points 3 and 6 important.

Additionally, Tufte, and Cleveland discuss and present a series of criteria for constructing high integrity graphs. They also provide style criteria for presenting effective graphical displays (Cleveland, 1985:100-101; Tufte, 1983:107-123). There is not universal agreement on high integrity criteria and style guide issues for graphs. Table 3 summarizes the viewpoints of several authors concerning graphical presentations. Table 4 summarizes the viewpoints of several authors concerning style guides for graphs. Both Table 3 and Table 4 replicate similar tables first created by Larkin which lists the high integrity graphics criteria and style guidelines and indicates which authors agree or disagree with each of the criteria (Larkin, 1990:21-25).

Results of Selected Graphical Experiments

The development of specific criteria is important, but it is equally important to empirically test those criteria to prove their

Table 3. Criteria For Creating High Integrity Graphics With The Authors Who Advocate Their Use (Larkin, 1990:21-25).

	AUTHOR													
CRITERIA FOR CREATING HIGH INTEGRITY GRAPHICS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Charts with an arithmetic scale Should begin at the zero base line in order to show the true variation in movements.	X	X	X	X	X	X	X	X	X	X	X	X	X	O
2. Use multiple scales cautiously.		X		X								X		
3. The dependent axis should employ a simple arithmetic scale.						X		X						
4. Do not extend the scale much beyond the highest or lowest points on the graph.		X		X							X	X		X
5. If multiple curves are shown, the same unit scale must be used for correct comparison.													X	
6. Use labels to defeat graphical distortion and ambiguity.	X		X	X					X			X		
7. Represent quantities by linear magnitudes as areas or volumes may be misinterpreted.	X			X	X	X			X	X				
8. For area graphs, the more irregular strata should be placed near the top.		X												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 3. Continued.

AUTHOR

CRITERIA FOR CREATING HIGH INTEGRITY GRAPHICS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
9. Time scale divisions must be equal.				X		X				X	X	X		
10. Keep your charts simple to add to clarity.			X								X	X	X	
11. The horizontal scale should usually be read from left to right; the vertical scale from bottom to top.					X									
12. The general arrangement of a graph should proceed from left to right.					X									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 3a. Table 3 Author Listing (Larkin, 1990:21-25).

TABLE REFERENCE NUMBER	AUTHOR	YEAR
1.	Tufte	1983
2.	Taylor and Anderson	1986
3.	Cox	1978
4.	Schmid	1954
5.	Joint Committee on Standards for Graphic Representation	1915
6.	MacGregor	1979
7.	Steinbart	1986
8.	Johnson, Rice and Roemmich	1980
9.	Spear	1969

Table 3a. Continued.

TABLE REFERENCE NUMBER	AUTHOR	YEAR
10.	Auger	1979
11.	Rogers	1961
12.	American Society of Mechanical Engineers	1979
13.	Lefferts	1981
14.	Cleveland	1985

Table 4. Style Guidelines For Creating Good Graphics (Larkin, 1990:21-25).

AUTHOR

"STYLE GUIDES" FOR CREATING GOOD CHARTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Scale breaks should be used for false origins.			X	X	X							X		
2. Graphics must not quote data out of context.	X													
3. Oblong shaped grids are preferred to square grids. Good standard proportions are two to three and three to four.				X								X		
4. The zero lines should be sharply distinguished.				X	X				X					
5. The curve lines should be distinguished from the grid ruling.					X				X		X	X		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 4. Continued.

AUTHOR

"STYLE GUIDES" FOR CREATING GOOD CHARTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
6. Try to include in the diagram numerical data.				X										
7. If the data is not included, give the data in tabular form accompanying the diagram.				X							X	X		
8. When shading, shade from the zero line to the curve.									X					
9. Vertical or horizontal shadings are not recommended.									X			X	X	
10. Patterned shadings should be of good contrast.									X			X		
11. Legends should make diagrams nearly self-explanatory.			X											
12. Scales should be such that linear relations are roughly 45 degrees to the X-axis.			X											
13. For column charts, the column should be the same width; spacing between is one-half the column width.						X			X					
14. Arrange columns systematically.			X						X		X			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 4. Continued.

AUTHOR

"STYLE GUIDES" FOR CREATING GOOD CHARTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15. When a large part of a grid is unnecessary, break the grid but retain the zero line.						X								
16. Eliminate all grid lines but those essential for easy reading.	X			X		X					X	X		
17. On multiple curve graphs, each curve should be the same width.						X					X			
18. If irregularities occur in the time sequence, include spaces for the missing columns.									X					
19. Avoid broken scales which give inaccurate impressions.				X						X		X		X
20. Standardized units of monetary measurements are better than nominal units.	X													
21. For most line charts, the maximum number of plotted lines should not exceed five; three or fewer is the ideal number.													X	
22. The simplest curve patterns are usually the most effective. A solid line is most useful.												X		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 4. Continued.

"STYLE GUIDES" FOR CREATING GOOD CHARTS	AUTHOR 1	2	3	4	5	6	7	8	9	10	11	12	13	14
23. Keep your charts as simple as possible to add to clarity.											X			X
24. Do not overdo the number of tick marks.														X
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 4a. Table 4 Author Listing (Larkin, 1990:21-25).

TABLE REFERENCE NUMBER	AUTHOR	YEAR
1.	Tufte	1983
2.	Taylor and Anderson	1986
3.	Cox	1978
4.	Schmid	1954
5.	Joint Committee on Standards for Graphic Representation	1915
6.	MacGregor	1979
7.	Steinbart	1986
8.	Johnson, Rice and Roemmich	1980
9.	Spear	1969
10.	Auger	1979
11.	Rogers	1961
12.	American Society of Mechanical Engineers	1979
13.	Lefferts	1981
14.	Cleveland	1985

validity. Several experiments have been conducted in which various criteria of good graphical presentations were violated. The next

several paragraphs will briefly describe some of the experiments conducted to date.

Taylor verified that the violation of specific criteria misled decision makers. In her experiment, she presented bank loan officers with two sets of graphs representing financial data from fictitious companies. One set of graphs was considered accurate while the other set violated high integrity graphics criteria and was considered misleading. The underlying data for both sets of graphs were identical. The net result was that the loan officers correctly interpreted the data using the high integrity graphs, but misinterpreted the data from the misleading graphs. In essence, these loan officers believed that the companies whose financial data were represented in the misleading graphs were performing better than those companies represented by the accurate graphs (Taylor, 1983:116-127).

Vogel, Dickson, and Lehman conducted an experiment in which students were asked to commit to taking time management courses. It was explained to the students that these courses would cost $15.00 per course and would take approximately six hours to complete. One group of students received a presentation concerning the course without visual support while another group of students received the same presentation with visual support (image enhanced graphics). Students receiving the visual support with the presentation planned on spending 16.4 percent more time and 26.4 percent more money on the courses. The authors claim that overall, using the time measure, the visual support yielded a "forty-three percent improvement in action" (Vogel, Dickson, and Lehman, 1986:5-6). The authors state that, "in particular, visual support can

be seen to have affected the perception of a presenter as being more concise, clear, making better use of supporting data, more professional, more persuasive, and more interesting" (Vogel, Dickson, and Lehman, 1986:7-8).

Tan and Benbasat conducted an experiment in which they tried to determine the correct graphical display given specific data extraction tasks. Specifically, they suggest that bar charts have high x-value anchoring while symbol and line graphs have moderate and low x-value anchoring. Bar charts and symbol plots have moderate y-value anchoring while line graphs have low y-value anchoring. Anchoring suggests that certain parts of a graph act as relevant cues for the reader. High x-value (y-value) anchoring would occur when data extraction tasks are closely associated with known, or unknown, x-axis (y-axis) values. Finally, bar charts have low entity anchoring and symbol plots and line graphs have moderate and high entity anchoring. In this case, entity anchoring refers data extraction tasks involving an entire dataset. Using a factorial design experiment, they were able to determine that there were no differences between the graphical formats in terms of interpretation accuracy. However, they did find that there was a statistically significant difference in terms of the time taken to perform data extraction tasks between the various graphical formats. When the mode of graphical presentation was correctly matched to the data extraction tasks (i.e. high x-value, y-value, or entity tasks), the experimental subjects were able to interpret the graphs faster than when the data extraction tasks were not correctly matched to the mode of graphical presentation (Tan and Benbasat, 1993:167-189).

Moriarity conducted an experiment in which he used schematic (Chernoff) faces to represent six years of financial trend data for 22 real world companies. The identity of the companies was masked to keep the experimental subjects from using prior knowledge. Additionally, seven of these companies had filed for Chapter 10 or 11 bankruptcy protection. The task given to the experimental subjects was to correctly forecast whether or not the companies would file for bankruptcy. Introductory accounting students were used as the experimental subjects because they were not believed to be sophisticated users of financial information. The faces were designed by computers. Each feature of the face such as the ears, eyes, nose, mouth, etc. was linked to a specific Dun and Bradstreet key business ratio. As the ratio changed from year to year, the feature would also change (through a strict mathematical transformation). When the ratios improved, a smiling face was presented, but as ratios became worse, the face would begin to frown. Experimental subjects were presented the financial information for the various companies using either; (1) faces without explanations of what they meant; (2) faces with a brief explanation; (3) financial information required to compute the key business ratios; or (4) the key business ratios. Moriarity found that forecasts of bankruptcy were significantly better when using faces incorporating the ratios both with, and without explanations. Additionally, the time taken to forecast for bankruptcy was significantly better using faces than when using the other modes of presentation. Specifically the average time to forecast whether a firm would go bankrupt under each presentation mode was; (1) 3 minutes, 29 seconds for faces without

explanation; (2) 6 minutes, 12 seconds for faces with explanation; (3) 7 minutes, 20 seconds for financial statement balances and; 8 minutes and 1 second for financial ratios. Moriarity suggests that for unsophisticated users of financial information, schematic faces may improve both the speed and accuracy of the decision process (Moriarity, 1979:205-223).

DeSanctis and Jarvenpaa conducted an experiment which tried to determine whether or not "bar graphs improve the accuracy of forecasting of financial statement information" (DeSanctis and Jarvenpaa, 1989:509). Within their experiment, they used either a graphical, tabular, or a combined presentation mode to represent earnings per share data. The experimental subjects (48 MBA students) provided more accurate forecasts of earnings per share when using graphical presentations versus numerical tabular data. Additionally, forecasts using combined tabular and graphical presentations were more accurate than those using only a graphical or tabular presentation. However, the results were significant at a 0.10 level of significance, but were not significant at a more strict 0.05 level of significance. DeSanctis and Jarvenpaa did find some support for the notion that the experimental subject's forecasts would improve as they learned how to interpret the graphical presentations. After a period of five trials, the graphical and combined displays outperformed the numeric data presentation even at a .05 significance level.

Table 5 summarizes some of the important statistical measures and outcomes of the experiments described above.

Table 5. Results of Selected Experiments.

Author	Date	Experimental Design	Findings	Statistic	n
Taylor	1983	Diff of Mean	Graphs violating high-integrity criteria were misinterpreted		162
			Semilogarithmic scale	p=.0000*	
			Discretionary presentation of years	p=.0000*	
			Multiple amount scales	p=.0000*	
			Financial statement presentation order	p=.0000*	
			Zero-based point of reference	p=.0124*	
			Strata chart	p=.0205*	
			Scale range	p=.0253*	
			Grid proportions	p=.3135	
Vogel, Dickson, & Lehman	1986	Factorial	Perceptions of the presenter more favorable in terms of being more:		≈315
			Prepared	p=.10	
			Concise	p=.001*	
			Professional	p=.05*	
			Clear	p=.001*	
			Persuasive	p=.05*	
			Credible	p=.10	

Table 5. Continued.

Author	Date	Experimental Design	Findings	Statistic	n
Vogel, Dickson, & Lehman	1986	Factorial	Continued:		≈315
			Interesting	p=.05*	
			Strong	p=.10	
			Attractive supporting data	p=.01*	
Tan & Benbasat	1993	Factorial	Accuracy of bars vs. symbols vs. lines:		72
			Session 1 (no difference)	p=.97*	
			Session 2 (no difference)	p=.99*	
			Time performance:		
			High x and y value Line > bar & symbol	p<.01*	
			Line better for High x low y value vs. High x and y value	p<.01*	
			Bar charts better for High x and y value vs. High x and low y value	p<.01*	
			High x and low y value Bar > symbol & line	p>.01*	
Moriarity	1979	Factorial	Accuracy of forecast:		
			Faces no expln. > faces expln.	t=.417	121
			Faces no expln. > balances	t=.333	144
			Faces no expln. > ratios	t=2.154*	146

Table 5. Continued.

Author	Date	Experimental Design	Findings	Statistic	n
Moriarity	1979	Factorial	Accuracy of forecast:		
			Faces expln. > balances	t=.713	131
			Faces expln. > ratios	t=2.450*	133
			Balances > ratios	t=1.852*	156
			Time performance:		
			Faces no expln. < faces expln.	t=12.946*	121
			Faces no expln. < balances	t=13.426*	144
			Faces no expln. < ratios	t=11.323*	146
			Faces expln. < balances	t=3.609*	131
			Faces expln. < ratios	t=4.176*	133
			Balances < ratios	t=1.656*	156
DeSanctis & Jarvenpaa	1989	Factorial	Presentation mode accuracy:		48
			Between all presentation modes	F=2.825	
			After learning effects:		
			Numeric < Graphics	F=4.278*	
			Numeric < Combined	F=5.511*	
			Graphic < Combined	F= .142	

* Considered statistically significant above the .05 level

The debate concerning graphical versus tabular presentations of data has been going on for many years with mixed results. Potential explanations such as complexity and task environment (i.e. spatial data extraction tasks, such as interpreting trends versus symbolic data extraction tasks, such as identifying specific values), have been suggested as causes for differing results (Vessey, 1991:219-220). Table 6, originally presented by Vessey, lists the results of several experiments comparing graphs to tables.

Several experiments have been conducted at AFIT within the past three years. The next several paragraphs report on the findings of those experiments.

Larkin conducted an experiment using AFIT students to determine the effects of violating specific high integrity graphics criteria. Specifically, he wanted to see if violating the criteria would lead to inaccurate conclusions concerning the data presented in graphs. The experiments tested the temporal/sign, strata, dimension, and multiple scaling criteria. The students were allowed 30 seconds to evaluate the graph and 15 seconds to answer questions concerning the graph. When the criteria for good graphs were violated, students in the experimental group consistently misinterpreted the graphs. The results were significant with an alpha level of .0712 or lower in all areas except multiple scaling (Larkin, 1990:56-63).

Kern tested 68 AFIT Professional Continuing Education students to see if manipulation of Tufte's Lie Factor had any effect on graphical interpretation. He found that "graphs formulated in violation of Tufte's Lie Factor can mislead decision makers" (Kern, 1991:43). His

Table 6. Table Versus Graphical Presentation Modes (Vessey, 1991:230).

Author	Types of Questions	Dependent Variables	Results Accuracy	Time
a. Analysis of paradigmatic spatial acquisition tasks				
Comparing patters of data:				
Washburn (1927)	Spatial	Accuracy	G>T	
Watson & Driver (1983)	Spatial	Accuracy	G=T	
Umanath et al. (1988)	Spatial	Accuracy	G>T	
Umanath et al. (1990)	Spatial	Accuracy	G>T	
Wainer & Reiser (1976)	Spatial	Time		G>T
Recognizing trends:				
Washburn (1927)	Spatial	Accuracy	G>T	
Interpolating values:				
Carter (1947)		Accuracy Time	G=T	 G>T
Carter (1948)		Accuracy Time	G=T	 G>T
b. Analysis of symbolic information acquisition tasks				
Point/value reading:				
Washburn (1927)	Symbolic	Accuracy	T>G	
Carter (1947)	Symbolic	Accuracy Time	T>G	 T>G
Carter (1948)	Symbolic	Accuracy Time	T>G	 T>G
Powers et al. (1984)	Symbolic	Accuracy Time	T>G	 T>G
Point/value recall:				
Umanath et al. (1990)	Symbolic	Accuracy	T>G	

experiment involved measuring the difference in perception between graphs constructed using high integrity criteria and those violating Tufte's Lie Factor. The graphs involved had lie factors of between 1.4 and 24.3. All graphs had a p-value of less than .1151, with several much lower. Finally, Kern reports that his results were significant, with a p-value of .0001 for graphs with positive trends and .0014 for graphs with negative trends (Kern, 1991:38-43).

Carvalho and McMillan found that graphs using scale breaks can be deceptive. One hundred and forty seven AFIT and Ohio State University students, plus additional DoD personnel participated in the experiment. The authors report that the "graphs with a scale break were interpreted differently from those without a scale break" (Carvalho and McMillan, 1992:56). As in other AFIT experiments, Carvalho and McMillan determined that the experimental subjects perceived graphs using scale breaks differently than those not using scale breaks. Furthermore, the degree to which the scale break violates Tufte's Lie Factor, was found to be significant. The larger the lie factor generated by the scale break, the greater the distortion of the experimental subject's perception. The results of their experiment were significant and showed that graphs containing only a small lie factor registered a p-value of .2349, while graphs containing large lie factors had a p-value of .0042. The authors also found that there were significant differences in interpretation of line graphs, but "a difference in interpretation was not evident for the combined bar graph responses" (Carvalho and McMillan, 1992:52). Finally, demographics were found to be significant when interpreting graphs. Specifically, differences were found in

graphical interpretation based upon the sex and the degree to which the experimental subject had worked with graphs in the past (Carvalho and McMillan, 1992:55-58, 104-116).

Another recent experiment conducted at AFIT was by Barber and Dunn. They tested 99 AFIT students and DoD personnel to see if iconic graphs were interpreted differently than traditional bar graphs. The results of their study suggest that there was no statistical difference between the interpretation of the two types of graphs. They did, however, find that there were preferences toward certain iconic graphs. Viewers of these graphs seemed to like, or prefer, the iconic presentation of data more than the traditional bar graph. Additionally, they found that the gender of those tested was not a factor in graphical interpretation. This finding was at odds with the results reported by Carvalho and McMillan (Barber and Dunn, 1992:77, 100).

Table 7 summarizes some of the important statistical measures and outcomes of the AFIT experiments described above experiments.

Fill Patterns and Chartjunk

The literature surrounding chartjunk and fill patterns is sparse, at best. However, most of the literature which does exist seems to support the notion that it is better to use less chartjunk rather than more. Nonetheless, some authors do suggest using various forms of chartjunk to include different types of fill patterns. For instance, Slater points out that today's graphics presentation software allows users to "produce color sides with bar charts and pie charts from

Table 7. Results of AFIT Experiments.

Author	Date	Experimental Design	Findings	Statistic	n
Larkin	1990	Pre-test/ Post-test	Graphs violating high-integrity criteria proved misleading:		63
			Rotated bar reversed x-axis	p=.6133	
			Area graph irregular strata at bottom of graph	p=.0000*	
			Bar chart use of volume vs. Linear magnitude	p=.0000*	
			Line chart reversed vertical scale	p=.0712	
			Line chart reversed x-axis time scale	p=.0004*	
			Bullseye chart mislabeled quadrants	p=.0098*	
Kern	1991	Pre-test/ Post-test	Positive and negative trend graphs formulated with lie factors > 1.05 and < .95 are misleading		68
			Lie factor = 24.3	p=.062*	
			Lie factor = 11.0	p=.0005*	
			Lie factor = 14.3	p=.0968	
			Lie factor = 11.1	p=.0026*	
			Lie factor = 1.7	p=.1079*	
			Lie factor = 1.4	p=.1151	

Table 7. Continued.

Author	Date	Experimental Design	Findings	Statistic	n
Carvalho & McMillan	1992	Pre-test/ Post-test	Graphs with scale breaks on the dependent axis are interpreted differently than graphs without a scale break	p=.0174*	147
			Graphs with dramatic lie factor	p=.0042*	
			Graphs with non-dramatic lie factor	p=.2349	
			Line graphs	p=.0000*	
			Bar graphs	p=.3002	
Barber & Dunn	1992	Pre-test/ Post-test	Analysis of Iconic graph presentation		99
			Iconic graph area manipulation doesn't affect perception	p=.5754	
			No preference between iconic area manipulation and traditional graph presentations	p=.0004*	
			Horizontal iconic graphs do not affect perception	p=.4438	
			No preference between horizontal iconic and traditional graph presentation	p=.3682	
			Vertical iconic graphs do not affect perception	p=.7642	

Table 7. Continued.

Author	Date	Experimental Design	Findings	Statistic	n
			No preference between vertical iconic and traditional graph presentation	p=.0012*	
			Gender does not affect the impression of iconic graphs		
			Male	p=.8026	
			Female	p=.8104	

* Considered statistically significant above the .05 level

imported spreadsheet data, illustrate their work and wrap multiple text fonts around clip art images" (Slater, 1991:35-36). Morgenstern suggests that a graphics user can "spiff up" a chart or graph by changing fill patterns or colors between bars or areas within the graph (Morgenstern, 1992:34). Finally, Holmes, responding to criticism by Tufte said, "Tufte in his insistence on absolute mathematical fidelity, remains trapped in 'the world of academia' and insensitive to 'the world of commerce,' with its need to grab an audience" (Patton, 1992:31). Unfortunately, very little has been accomplished in terms of empirically testing the notion that chartjunk or fill patterns affect the perception or decision making of the viewer of a graph. Table 8 is a condensed version of Table 3 and Table 4 and lists chartjunk components and which authors support those components.

Table 8. Chartjunk Components With The Authors Who Advocate Minimizing Their Use (Larkin, 1990:21-25).

CHARTJUNK COMPONENT	AUTHOR 1	2	3	4	5	6	7	8
1. When shading, shade from the zero line to the curve.				X				
2. Vertical or horizontal shadings are not recommended.				X		X	X	
3. Patterned shadings should be of good contrast.				X		X		
4. Eliminate all grid lines but those essential for easy reading.	X	X	X		X	X		
5. Keep your charts as simple as possible to add to clarity.	X				X			X
6. Do not overdo the number of tick marks.	X							X
7. Avoid interior decoration of a graph.	X							

Table 8a. Table 8 Author Listing.

TABLE REFERENCE NUMBER	AUTHOR	YEAR
1.	Tufte	1983
2.	Schmid	1954
3.	MacGregor	1979
4.	Spear	1969
5.	Rogers	1961
6.	American Society of Mechanical Engineers	1979
7.	Lefferts	1981
8.	Cleveland	1985

Despite the lack of empirical evidence, some authors believe that chartjunk and fill patterns serve no purpose and may even distort the accurate perception of the underlying data of a graph. For example, Tufte claims, "the interior decoration of graphics generates a lot of ink that does not tell the viewer anything new" (Tufte, 1983:107). Furthermore, he says that chartjunk, especially the types which exploit the moiré effect are "inevitably bad" and that shades of gray or specific labeling should be used instead (Tufte, 1983:108, 111). Finally, Tufte claims that the improper use of chartjunk and fill patterns clouds the flow of information from the graph to the viewer (Tufte, 1983:108).

Cleveland claims one of the primary criteria for constructing good graphs is to avoid clutter within the data region. He states that when a graph is cluttered, "it is hard to visually disentangle what is graphed" (Cleveland, 1985:36). He goes on to state:

> There are many ways to obscure the data, such as allowing other elements of the graph to interfere with the data or not making the graphical elements encoding the data visually prominent. We should eliminate superfluity in graphs. Unnecessary parts of a graph add to the clutter and increase the difficulty of making the necessary elements - the data - stand out. (Cleveland, 1985:24)

A manual produced by CalComp, a subsidiary of Lockheed, describes good overhead presentation methods, and suggests that preparers of graphs and charts, "keep the so-called chartjunk - tick marks, grids, labels, and decorations - to a minimum. Emphasize the data, not the design" (Master Graphics, 1990:5). The manual also claims, with regards to pie charts, that colors should be used rather than cross-hatching

type fill patterns because the fill patterns make it harder to accurately compare slice proportions (Master Graphics, 1990:3).

Despite the concerns of Tufte and Cleveland, fill patterns and visual supports, to include chartjunk and fill patterns, are used to help promote or sell ideas and products. As stated previously, a study by Vogel, Dickson, and Lehman found that students subjected to presentations using visual supports, to include graphics, planned to spend more time and money on specific academic programs than students not subjected to the visual supports (Vogel, Dickson, and Lehman, 1986:5-20).

In a similar study, Jarvenpaa claimed that the decision process is strongly contingent on the graphical presentation format:

> A graphical presentation format is a part of a task environment, and changes in a presentation format can lead to changes in the decision strategies used. Specifically, the way the graphical information is arranged on a display affects the order in which decision makers acquire information. (Jarvenpaa, 1987:298)

The previous discussion underscores the controversy concerning whether graphical displays which are enhanced through decoration of the data region can, in fact, influence decision makers. Several authors, as referenced by Table 8 above, believe that chartjunk and fill patterns are unnecessary and should not be used. Nonetheless, some research findings seem to indicate that the method of graphical display, which may include chartjunk and fill patterns, can be important to decision making activities.

Conclusion

Most of the articles surveyed noted significant increases in computer technologies and associated graphic software. The proliferation of graphic software has made it possible for virtually any company or organization to prepare professional graphics (Christensen and Larkin, 1992:130; Taylor and Anderson, 1986:135).

One common underlying theme or concern of the various authors is that the skills and abilities of both those who present graphs and those who use them in the decision making process have not kept pace with the proliferation of software applications and technology (Christensen and Larkin, 1992:130-131; Jarvenpaa and Dickson, 1985:2; Johnson and Rice, 1990:50; Steinbart, 1989:60; Taylor and Anderson, 1986:126, 135).

Research into investigative question one (What standards have been developed to ensure the integrity of graphical presentations and the use of chartjunk?), showed that there are numerous standards which have been developed for graphical presentations. As a result of the concern over misleading graphs, several researchers suggested specific criteria to ensure the integrity of the underlying data within the graph. Tufte developed an equation which accurately measures the degree of distortion in a graph (Tufte, 1983:56-57). Additionally, Tufte, Cleveland, Christensen and Larkin, Taylor and Anderson, plus several other authors propose specific criteria for the production of high integrity graphs. Graphs constructed by applying their criteria should present data in a clear and concise manner (Christensen and Larkin, 1992; Cleveland, 1985; Taylor and Anderson, 1986; Tufte, 1983). Finally, several style guides,

which include aspects of chartjunk have been developed. Table 3 and Table 4 summarized many of those standards.

To answer investigative question two, a review of graphical experiments was conducted. These experiments verified empirically that violating specific criteria may cause the readers of graphics to be misled because of distortions of data contained in the graph (Carvalho and McMillan, 1992; Johnson and Rice, 1990; Kern, 1991; Larkin, 1990; Steinbart, 1989; Taylor, 1983). Also, Johnson and Rice, and Steinbart detected deceptive graphs within annual reports (Johnson and Rice, 1990:50-52, 55-56; Steinbart, 1989:63-70). Tables 5, 6, and 7 summarized the results of the experiments listed within this chapter. Despite a substantial number of experiments concerning graphical presentations, no experiments could be found which empirically verified the effects on perceptions or decision making when graphs included forms of chartjunk. Barber and Dunn's experiment measuring the effects of iconic graphs represents the closest efforts at measuring chartjunk issues to date. As a result of the lack of guidelines and empirical evidence on the effects of chartjunk, an experiment was conducted in which specific forms of chartjunk were manipulated. The results of that experiment are reported in Chapter IV of this thesis.

Finally, in researching investigative question four (What preferences exist concerning various forms of chartjunk versus graphical presentations which do not contain chartjunk?), this chapter discussed the fact that many authors do not believe chartjunk or fill patterns are appropriate. Table 8 summarized aspects of chartjunk which various authors felt should be eliminated or kept to an absolute minimum.

Furthermore, some authors suggest that they may even distort the viewer's perception of the graph (Cleveland, 1985:24, 36; Tufte, 1983:107-108, 111). Additionally, some studies show that graphical formats and supports may be capable of manipulating the decision made by the viewer of the graphic (Jarvenpaa, 1987:298; Vogel, Dickson, and Lehman, 1986:5-20).

III. Methodology

This chapter describes the methodology used to research investigative questions and the hypotheses concerning whether fill patterns can affect interpretation of the underlying data of a graphical display. Within this chapter, there are nine sections. Section one gives a brief introduction to the objectives of this research project and its associated hypotheses and investigative questions. Section two discusses the factorial experimental design used during the behavioral experiment conducted on graphical interpretation. Section three outlines the specifics of how the experimental package was developed. Section four explains key elements of the statistical procedures used throughout the experiment. Section five discusses concerns regarding internal and external validity with regards to this research and discusses issues and concerns regarding the sample population. Section six deals with specifics of constructing the experimental package. Section seven describes how the experiment was administered. Section eight describes the construction of the End-of-Exercise Questionnaire. Finally, section nine briefly summarizes the first eight sections.

Introduction

The primary objective of this study is to determine if bar graphs with fill patterns inside the bars affect perception, interpretation, or decision making. The investigative questions are as follows:

1. What standards have been developed to ensure the integrity of graphical presentations including those which contain chartjunk?

2. Is there empirical evidence to support the proper use of graphs to include those containing chartjunk?

3. Are there any demographic trends related to chartjunk and graphical interpretation?

4. What preferences exist concerning various forms of chartjunk versus graphical presentations which do not contain chartjunk?

The primary null hypotheses (H_0) for this research follow:

1. Manipulation of the mode of presentation and trend of data do not affect decision making.

2. Manipulation of the mode of presentation and trend of data do not affect interpretation of the significance of a trend.

3. The manipulation of the mode of presentation and trend of data do not affect the perception of confidence in decision making.

4. The manipulation of the mode of presentation and trend of data do not affect the perception of risk in decision making.

5. The manipulation of the mode of presentation and trend of data do not affect the confidence of decision making.

6. Gender does not affect decision making.

Investigative questions 1, 2 and 4 were answered in Chapter II, Literature Review. A behavioral experiment using ink and white paper copies of computer presentations, presented in a business scenario, were used to answer the primary hypotheses. Investigative question 5 was answered by inserting demographic questions in an end-of-exercise questionnaire placed at the back of the experimental package. Specifics of how the experiment and end-of-exercise questionnaire were designed, administered, and analyzed follows.

Experimental Design

To test investigative question 3 and the primary hypotheses, a completely randomized factorial experimental design was used. This experimental design was chosen because of the need to analyze the main and interactive effects of the two experimental variables of interest, that of trend and presentation mode. Information obtained from factorial experiments is more complete than that obtained from a series of single factor experiments because only a factorial experimental design will permit the evaluation of interaction effects (Winer, 1971: 309). An interaction effect is an effect attributable to the combination of variables above and beyond that which can be predicted from the variables considered singly (Winer, 1971: 309).

A factorial experiment permits the researcher to make decisions that have a broad range of applicability. In addition to information about how the experimental variables operate in relative isolation, the researcher can predict what will happen when two or more variables are used in combination with one another (Winer, 1971:309).

The design of a factorial experiment is concerned with answering the following questions (Cox, 1958:23):

1. What factors should be included?

2. How many levels of each factor should be included?

3. How should the levels of the factors be spaced?

4. How should the experimental units be selected?

5. How many experimental units should be selected for each treatment combination?

6. What steps should be used to control experimental error?

7. What criterion measures should be used to evaluate the effects of the treatment factors?

8. Can the effects of primary interest all be estimated adequately from the experimental data that will be obtained?

The answers to these questions will be addressed in detail in this chapter and the chapters that follow.

The Experiment

The factorial experiment was designed to analyze the manipulation of two factors, Trend and Mode of Presentation, to determine their effects on the response variables of decision making, degree of confidence, degree of risk, and significance associated with the trend of numerical information. For the purposes of this research, the term factor is used interchangeably with the terms treatment and experimental variable. More specifically, a factor is a series of related treatments or related classifications (Winer, 1958:311).

The number of levels within the factor are determined mainly by the degree to which the experimenter desires to investigate each factor (Winer, 1971:311). Additionally, the levels of the factor are basically determined by the kinds of inferences the experimenter wishes to make upon conclusion of the experiment. In this experiment, three separate levels were chosen for the experimental variable Trend: increasing, decreasing, and constant trends of numerical information; four levels were chosen for the experimental variable Mode of Presentation: vertical bar graphs containing light, medium, and heavy cross-hatching, and a tabular presentation mode. The specific numerical information used to create the various graphs are contained in Appendix B. The experimental

variables, Trend and Mode of Presentation along with their associated levels, are all qualitative variables and were analyzed as such in the experiment.

When the number of levels of a factor included in an experiment are equal to the entire population of factors, then that factor is considered to be fixed. Also, when the selection of the levels for a particular factor are determined by some systematic non-random procedure, then that factor is also considered to be a fixed factor (Winer, 1971:313). In this experiment, the levels chosen for the experimental variables of interest were selected in a non-random systematic manner prior to execution of the experiment. Therefore, the factors of Trend and Mode of Presentation are evaluated in the experiment as fixed factors.

Dimensions of a factorial experiment are indicated by the number of factors and the number of levels of each factor. The dimensions of this experiment which contains two factors, Trend with three levels and Mode of Presentation with four levels, is described as a 3 X 4 (read "three by four") factorial design. The treatment combinations in this 3 X 4 factorial experiment are represented schematically as follows:

Levels of Factor M (Mode of Presentation)

		m_1	m_2	m_3	m_4
Levels of	t_1	tm_{11}	tm_{12}	tm_{13}	tm_{14}
factor T	t_2	tm_{21}	tm_{22}	tm_{23}	tm_{24}
(trend)	t_3	tm_{31}	tm_{32}	tm_{33}	tm_{34}

In this schematic, t_1, t_2, and t_3 designate the levels of factor T (Trend); m_1, m_2, m_3, and m_4 designate the levels of factor M (Mode of Presentation). In this 3 X 4 factorial experiment, twelve possible experimental treatment combinations were formed (i.e., t X m different treatment combinations are possible).

Implementation of an analysis of variance model requires determination of appropriate sample sizes (Neter, Wasserman, and Kutner, 1990:633). The proper planning of sample sizes for ANOVA problems provides protection against Type I error (deciding the null hypothesis is false when in fact it's true) and Type II error (accepting the null hypothesis when it is false) so that the estimates of interest have enough precision to be useful.

The procedure used in the experiment to determine the sample size (n) was the power approach (Neter, Wasserman, and Kutner, 1990:634).

The power approach uses the power of the F test to determine the probability that the decision rule will lead to a Type II error. To calculate the power of the F test, the following equation is used:

$$Power = P\{F^{*} > F(1 - \alpha;\ r - 1,\ n_T - r) \mid \phi\} \tag{2}$$

Where F is the test statistic used to compare variances, α is the probability of a Type I error, r is the number of factor levels, n_T is defined as n*r, ϕ is the noncentrality parameter, that is a measure of how unequal the μ_i are, and where ϕ is calculated as follows:

$$\phi = \frac{1}{\sigma}\sqrt{\frac{\sum n_i(\mu_i - \mu_.)^2}{r}} \tag{3}$$

Where σ is the standard deviation, n_i is the factor level sample size, μ_i is the factor level sample mean, and where $\mu.$ is the mean of the sample means and is calculated as follows:

$$\mu. = \frac{\sum n_i \mu_i}{n_T}, \quad n_i = n, \quad T = factor\ levels \tag{4}$$

In planning the sample size for this experiment, the minimum range of factor level means used to detect differences between the μ_i with high probability was required. This minimum range is denoted by Δ and was determined to be $10,000 from the pilot study results. The variable, Δ, was calculated using:

$$\Delta = \max(\mu_i) - \min(\mu_i) \tag{5}$$

In addition to determining Δ, the magnitude of σ, the standard deviation of the probability distribution of Y (Y is the population distribution), was also required. This was derived from analysis of the pilot study conducted and was determined to be 7556.0.

The variables Δ and σ were then used to calculate the following ratio:

$$\frac{\Delta}{\sigma} = \frac{10,000}{7556} = 1.32 \tag{6}$$

Power of the F tests were then used to plan the sample sizes (Neter, Wasserman, Kutner, 1990:1151-1152). In addition to the Δ/σ ratio, two other specifications were required to use the power charts:

1. The level of α which the risk of making a Type I error is to be controlled.

2. The level β at which the risk of making a Type II error is to be controlled.

With this information, it was determined that at the $\alpha = .05$, and $\beta = .2$, a sample size of 15 per cell would be required in the factorial experiment to protect against Type I and II errors.

In the experiment, elements observed under each of the treatment combinations were extracted from the population of interest. Specifically, the elements were taken from the target population of mid and upper level Department of Defense (DoD) managers attending PCE course. A total of 15 elements (n) were observed under each treatment combination in the experiment. This required a total of n*t*m elements from the population (180 people). The n*t*m subsamples were then subdivided at random into t*m subsamples of n=15 each. These subsamples were then assigned at random to the twelve treatment combinations.

Statistical Analysis

The general format used to identify the differences between the various experimental treatment means within the factorial designed experiment was the application of a Multifactor Analysis of Variance (ANOVA) technique. This technique determines the effects of the factors of Trend and Mode of Presentation on the primary response variable decision making. A Multifactor ANOVA is very effective when two or more factors affect a key response variable (John, 1971:66). The procedure was used to analyze the effects of the factors Trend and Mode of

Presentation on several decision making response variables and allowed a comparison between treatment means to be made.

Additionally, a Multifactor ANOVA was used to conduct analysis of questions one through ten contained in the end-of-exercise questionnaire. In these questions, the procedure allowed a determination to be made concerning any correlations that existed between Trend and Mode of Presentation and perceptual interpretations.

The following ANOVA model suited for a two-factor experimental design was used to test Null Hypotheses 1 through 4:

$$Y_{ij} = \mu + M_i + T_j + MT_{ij} + \epsilon_{ij} \qquad (7)$$

where μ is a constant, M_i represents the main effect of the factor Mode of Presentation (i = 1,...,4, where 1 = vertical bar graphs with no cross-hatching inside the bars, 2 = vertical bar graphs with a light intensity of cross hatching, 3 = vertical bar graphs with a heavy intensity of cross-hatching, 4 = a tabular data mode of presentation), T_j represents the main effect of the factor trend (j = 1,...,3, where 1 = an increasing trend, 2 = no change in trend, and 3 = a decreasing trend), MT_{ij} represents the interaction effect of both factors Mode of Presentation and Trend, ϵ_{ij} represents the experimental error term.

A one-way ANOVA was also used to determine if there was any statistical difference between uniquely defined groups. This involved the analysis of the demographic data with various demographic factors considered to be treatments. This data were categorical in format.

The experiment tested all hypotheses based on a completely random and independent sampling of the population. The variances of the

populations were unknown but assumed to be equal. The test for population normality used for this research was the Wilk-Shapiro/Rankit Plot (<u>Statistix User's Manual</u>, 1991:242).

The level of significance α was set at .05 for all tests. If a p-value was obtained which was less than or equal to the stated α, we rejected the null hypothesis with a confidence level of 95 percent.

The primary focus of our research was to determine if the Mode of Presentation (i.e. graphical with three levels and tabular data) made any significant statistical difference on decision making and perceptions of the population being tested. To focus in on the main effects of this factor, the data of all dependent response variables for Company A and B were normalized to negate the effects of bias created by the decision rule. By normalizing the response variables, the data were then objectively analyzed to determine the effects both factors had on decision making. The data were normalized by using the range scale of \$50,001 to \$70,000 for increasing trend scale and adding either \$20,000 or \$40,000 respectively to the no change and decreasing trend responses. This simple procedure allowed for a more accurate analysis of a difference between the different factor level treatment combinations to be made. The example below illustrates how each response variable was normalized:

Example 1: If the response data were between \$50,001 - \$70,000, the data was left unchanged.

Example 2: If the responses were between \$10,000 - \$30,000, (data representing a decreasing trend interpretation) \$20,000 was added to each response.

Example 3: If the responses were between \$30,001 - \$50,000, (data representing a no change trend interpretation) \$40,000 was added to each response.

By using a completely randomized design to conduct the 3 X 4 factorial experiment, an "F" statistic could be used to calculate the measure of treatment mean variability (MST) and the measure of sampling variability (MSE). The F statistic allowed an evaluation to be made on whether or not there were any statistical differences in uniquely defined groups within the experiment. Specifically, ANOVA was used to analyze differences in treatment means associated with the experimental variables of Trend and Mode of Presentation.

Hypothesis-testing procedures using the F statistic are based on certain assumptions that are necessary for the mathematical justification of the procedure. Because F is a random variable formed from the ratio of two independent Chi-square variables, it follows that the assumptions of χ^2 are also the assumptions of F. A basic assumption of the χ^2 distribution is that the population is normally distributed. It is further assumed that random sampling from a normally distributed population is employed. It follows from the definition of a random sample that the selection of one observation is independent of another observation.

In summary, hypothesis testing based on the F statistic as the theoretical model involves the following assumptions:

1. Observations are drawn from normally distributed populations.
2. Observations represent random samples from populations.
3. Variances of the populations are equal.

4. Numerator and denominator of the F ratio are independent (Kirk, 1968:220).

The following paragraphs will describe the statistical tests used, followed by a brief example of each. Each example uses dummy data. Additionally, exact steps needed to conduct the tests using Statgraphics software are contained in the Statgraphics User's Manual (1992). The test statistic is identified by an "F".

In calculating the ANOVA in the factorial experiment, several F statistics were derived to conduct a complete analysis of the main and interactive effects of the experimental variables on all response variables. Additionally, the F statistic was used to determine if there were any statistical differences in uniquely defined groups within the experiment such as those defined by demographic characteristics. The formula for "F" is:

$$F = \frac{MST}{MSE} \tag{8}$$

Additionally, the formulas for computing MST and MSE are as follows:

$$MST = \frac{\sum_{i=1}^{p} n_i(\bar{y}_i - \bar{y})^2}{p - 1} \tag{9}$$

$$MSE = \frac{\sum_{j=1}^{n_1} (\bar{y}_{1j} - \bar{y}_1)^2 + \ldots + \sum_{j=1}^{n_p} (\bar{y}_{rj} - \bar{y}_r)^2}{n - p} \tag{10}$$

where MST is the unbiased estimator of σ^2, MSE is an unbiased estimator of the common variance σ^2, Y represents the overall mean

response, and p represents treatments. The following examples illustrate how the F statistic was used to test hypotheses in the behavioral experiment.

One of the hypotheses that was listed using the F statistic was the hypothesis that the gender of the respondents doesn't affect their decision making ability. To list this hypothesis, we conducted a single test to find out whether the gender of the respondents affected the mean responses of the loan decisions made for each company. The null hypothesis we tested was H_0: $\mu_1 = \mu_2 = \ldots = \mu_{12}$. The primary purpose for making such a test was not to prove that the population means are equal, rather, to see if the differences between the means are too small to justify rejecting the null hypothesis. The example that follows illustrates how this hypothesis was tested. Dummy data were used to conduct the test.

To test a hypothesis similar to the one performed in this experiment, an example using a single-factor will be used to illustrate how the hypothesis were investigated.

For example, if interest is centered on the effects of gender on loan decision making, a one-way ANOVA test can be used to test the effects of gender on the mean loan decisions made to see if a difference exists. Because gender is the only factor investigated, the experiment is a single-factor experiment at two fixed levels. These levels are also qualitative levels since no numerical value can be assigned to gender. In this example, ten observations were used for testing each sex. The mathematical model for the test is:

$$Y_{ij} = \mu + \alpha_i + \epsilon_{ij} \qquad (11)$$

where Y_{ij} = response of the $_{ij}$th treatment combinations, μ = the constant, α_j = effect of the $_j$th level of the factor gender, ϵ_{ij} = the experimental error term.

There are two treatments (male/female) and ten observations per treatment. The dummy data for this example are shown in Table 9.

Table 9. Dummy Data For Gender ANOVA.

Gender	
Male	Female
\$56,000	\$45,000
55,000	46,000
62,000	45,000
59,000	39,000
60,000	43,000
64,000	42,000
50,000	39,000
55,000	45,000
56,000	43,000
61,000	41,000

Statgraphics was used to calculate the one-way ANOVA for this example. The significance level set for the ANOVA test was α = .05. The one-way ANOVA results are reproduced in Table 10.

To test H_0: $\alpha_j = 0$ for all $_j$ = 1 and 2, the test statistic used from Table 10 was calculated as

$$F = \frac{MST}{MSE} = \frac{1.1250E0009}{1.1844E0007} = 94.981 \tag{12}$$

From Table 10, it can be seen that the F statistics has a high value which indicates that there is a statistically significant

Table 10. Gender One-Way Analysis of Variance.

Analysis of variance

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. Lvl
Between groups	1.1250E0009	1	1.1250E0009	94.981	.0000*
Within groups	2.1320E0008	18	1.1844E0007		
Total (corrected)	1.3382E0009	19			

* denotes a statistically significa t difference

difference between population means with regards to gender. This suggests rejection of the hypothesis and a claim that there is a considerable difference in average loan amounts given between the two sexes. It should be noted again that this conclusion was derived from dummy data. One-way ANOVA was conducted on all demographic versus the conclusions on the primary response variables (Carvalho and McMillan, 1992:39-42).

As mentioned previously, to test the primary hypotheses in the experiment, a two-factor ANOVA was employed. To illustrate how tests were conducted on the two-factor model used in the experiment, an example studying decision making using four different modes of presentation at three different trend levels - increasing, decreasing, and no trend will be examined. This particular type of experiment would require utilizing 4 X 3 = 12 mode of presentation-trend combinations. The layout of this experiment is given in Table 11.

Table 11. Mode of Presentation Versus Trend Experiment Layout.

		Levels of Factor M (mode of presentation)			
		m_1	m_2	m_3	m_4
Levels of	t_1	tm_{11}	tm_{12}	tm_{13}	tm_{14}
factor T	t_2	tm_{21}	tm_{22}	tm_{23}	tm_{24}
(trend)	t_3	tm_{31}	tm_{32}	tm_{33}	tm_{34}

The mathematical model used is

$$Y_{ijk} = \mu + M_i + T_j + (MT)_{ij} + \epsilon_{ijk} \tag{13}$$

Y_{ijk} is a response (in this case loan response),

μ is a constant,

M_i represents the main effect of the factor Mode of Presentation, (i = 1,...,4, where i = presentation type),

T_j represents the main effect of the factor Trend (j = 1, 2, and 3, where 1 = increasing trend, b = no trend, and c = decreasing trend),

$(MT)_{ij}$ represents the interaction effect of both factors Mode of Presentation and Trend,

ϵ_{ijk} represents the experimental error term.

The research hypotheses leading to this experiment can be evaluated by means of a multiple ANOVA of the following null hypotheses (Kirk, 1968:174):

1. Test for t Treatment Means:

   H_0: No difference among the t treatment means

   H_a: At least two treatment means differ

2. Test for m Treatment Means:

   H_0: No difference among the m treatment means

   H_a: At least two treatment means differ

3. Test for Factor Interaction:

   H_0: Factors T and M do not interact to affect the response mean

4. Test for Main Effect of Factor M:

   H_0: No difference among the m mean levels of factor M

   H_a: At least two mean levels of factor M differ

5. Test of Main Effect of Factor T:

   H_0: No difference among the t mean levels of factor T

   H_a: At least two mean levels of factor T differ

A total of 48 dummy loan values were created. The loan values are randomly divided into twelve subsamples representing four loans each. The subsamples were randomly assigned to the twelve treatment combinations of the 4 X 3 factorial design. All treatment levels of interest to the experiment are included. Thus, a fixed-effects model, Model I (described in this chapter) applies to this example. Table 12 represents the dummy data used in this example.

Statgraphics was used to calculate tests three through five (multiple ANOVA) for this example. The significance level set for the test was $\alpha = .05$. The multiple ANOVA results are given in Table 13.

Table 12. Dummy Data For Loan Decision ANOVA (in $1,000).

Trend Level	Mode of Presentation (1)	(2)	(3)	(4)
	14.3	18.1	17.6	15.7
(1)	14.5	17.6	18.2	17.5
	11.5	17.1	18.9	16.7
	13.6	17.6	18.2	16.6
	12.1	10.5	15.7	17.5
(2)	12.6	12.8	17.5	14.3
	11.2	8.3	16.7	15.1
	11.0	9.1	16.5	16.2
	13.7	12.2	16.2	14.4
(3)	12.2	13.3	17.1	12.9
	10.7	11.7	17.0	13.7
	11.1	10.9	16.7	14.1

Table 13. Analysis of Variance For Loan Decision.

Analysis of Variance

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
A:Mode of Presentation	168.33500	3	56.111667	51.492	.0000*
B:Trend	89.34042	2	44.670208	40.992	.0000*
INTERACTIONS					
AB	61.311250	6	10.218542	9.377	.0000*
RESIDUAL	39.230000	36	1.0897222		
TOTAL (CORRECTED)	358.21667	47			

* denotes a statistically significant difference

To analyze the test for factor interaction and the main effects of the factors, the F statistics listed in Table 13 were used. These test statistics indicate that there is a statistically significant difference that can be attributed to the interaction of both factors. In addition, there are statistically significant effects caused by both factors. Based on the significance of the F statistics from Table 13, the null hypotheses for tests 2, 3, and 4 can be rejected at the $\alpha = .05$ significance level. Thus, it can be concluded that both factors interact to affect the loan decision and that there are differences among the mode of presentation and trend mean levels for both factors.

The analysis of the test for treatment means was conducted by using multiple range analysis on the various treatment means. Statgraphics output of the multiple range analysis for the factors mode of presentation and trend level are contained in Tables 14 and 25 respectively. The significance level set for the test was $\alpha = .05$.

As can be seen from Tables 14 and 15, there are at least two treatment means that differ for both factors. Therefore, the null hypotheses for tests 1 and 2 are rejected at the $\alpha = .05$ significance level. The X marks under the heading Homogeneous Group is meant to show visually that factor levels are either heterogeneous (not similar) or homogeneous (similar). Homogeneous levels would be represented by X marks following one another in the same column. By observing the tables, it can be concluded that all levels of the factor Mode of Presentation are heterogeneous and only the no trend and decreasing trend levels of the factor Trend are homogeneous.

Table 14. Multiple Range Analysis For Loan Decision by Factor Mode of Presentation.

Multiple Range Analysis

Level*	Count	LS Mean	Homogeneous Groups
1	12	12.383333	X
2	12	13.266667	X
4	12	15.391667	X
3	12	17.191667	X

contrast	difference	+/- limits	
1 - 2	-0.88333	0.86451	**
1 - 3	-4.80833	0.86451	**
1 - 4	-3.00833	0.86451	**
2 - 3	-3.92500	0.86451	**
2 - 4	-2.12500	0.86451	**
3 - 4	1.80000	0.86451	**

* denotes levels of factor (i.e., level = presentation type 1 - 4)
** denotes a statistically significant difference.

Table 15. Multiple Range Analysis For Loan Decision by Factor Trend.

Multiple Range Analysis

Level*	Count	LS Mean	Homogeneous Groups
2	16	13.568750	X
3	16	13.618750	X
1	16	16.487500	X

contrast	difference	+/- limits	
1 - 2	2.91875	0.74869	**
1 - 3	2.86875	0.74869	**
2 - 3	-0.05000	0.74869	

* denotes levels of factor (i.e., level = trend 1 - 3)
** denotes a statistically significant difference.

Again, it should be noted that the above conclusions were derived from dummy data. The multiple ANOVA and multiple range tests were conducted on the loan responses for fictitious Company's A and B, as well as the first ten responses contained in the end-of-exercise questionnaire.

Internal and External Validity of The Factorial Design

Within this section, internal and external validity concerns will be briefly discussed.

Internal Validity. One of the major advantages of using the factorial design is its high degree of internal validity. Internal validity is determined by how well the experiment measures what it claims to measure. Additionally, Emory suggests that internal validity is a measure of how well "the conclusions we draw about a demonstrated experimental relationship truly imply cause" (Emory, 1991:424). Emory goes on to list seven internal threats to validity which are as follows:

1. History - the potential that some events may occur which can confuse or influence the relationship being studied.

2. Maturation - changes which may take place within the subject which are a function of time and which may influence the subject's responses, i.e. fatigue, hunger, boredom.

3. Testing - the potential for the subject to learn as a result of the testing procedure. Scores may improve from one test to the next.

4. Instrumentation - the potential for differing responses due to changes in the test instrument or observer.

5. Selection - the potential for differing responses due to differences in the subjects assigned to the control group versus the experimental group. In essence, the control and experimental group should be identical in all aspects. Randomly assigning subjects to the experimental and control group will largely eliminate this threat to validity.

6. Statistical Regression - scores should not be based on extreme values.

7. Experiment Mortality - this threat to internal validity exists when the composition of the experimental or control group changes over time. The results of experiment mortality hinder conclusions drawn between the experimental and control group. (Emory, 1991:424-427)

For this experiment, history was not a factor because the experiment was administered only one time. The entire experiment takes less than 20 minutes which eliminates the vast majority of any historical factors. Additionally, all subjects were given the experiment in the same classroom. Thus, any historical event will be equally present among all subjects.

Maturation was not a factor because of the short time span of the test instrument. With the test taking 20 minutes or less, boredom, fatigue, and hunger should not have affected the results of the test.

Testing should not be a factor because all tests for each fictitious company were completed by the subjects at the same sitting. Additionally, subjects only take the test one time, thus, eliminating any opportunity for learning between subsequent tests.

Instrumentation should not be a factor in this research because all subjects were administered exactly the same tests by the same administrators and in similar classroom settings.

Selection was controlled by randomly assigning subjects to different treatment combinations within the factorial experiment. Additionally, randomization helped control the effects of nuisance, or confounding variables (Moen, 1991:73-75). Furthermore, Stanley and Campbell also maintain that randomization controls for other unwanted

factors causing problems in an experiment (Campbell and Stanley, 1966: 23-24).

Statistical regression should not be a problem because of the randomization procedures used for assigning subjects to the experimental treatment combinations.

Experimental mortality was controlled for by the brevity of the test. The experiment was administered immediately following the instructions and so no subjects dropped out during administration of the experiment itself.

<u>External Validity.</u> External validity measures the degree to which the results of the experiment can be generalized to the overall population. According to Emory, there are three major threats to external validity as follows:

> 1. Reactivity of testing on X. This threat to validity suggests that sensitizing the subjects by use of the pretest may affect their responses in the posttest.
>
> 2. Interaction of selection and X. If the population from which the subjects are drawn is not the same or is only a subset of the more general population, generalization to the population as a whole will be diminished.
>
> 3. Experimental setting. The unrealistic and controlled environment used in experimental design may in and of itself bias the results. The main cause for this phenomena is that the subjects may be aware of the fact that they are being observed. This knowledge may affect their responses. Additionally, there may be a tendency for the subjects to role play (Emory, 1991:427-428)

Additionally, Campbell and Stanley suggests that there is a multiple treatment inference threat to external validity. This occurs when the subjects are repeatedly tested. The effects of prior treatments cannot be erased and affect the responses for the current test (Campbell and Stanley, 1966:6).

Reactivity of testing on X is non-existent because none of the subjects received a pretest prior to the experiment.

Interaction of selection and X was reduced by random selection of the subjects to the various treatment combinations. However, the fact that all subjects are associated with the DoD may limit this research effort's ability to generalize to the overall population. More will be said about the sample population in the Sample Population section.

Experimental setting bias was limited by conducting the experiment in the subject's classroom. Subjects were familiar with the classroom environment and were less anxious concerning the experiment. However, the subjects were aware they were being observed which may limit generalization of the research results to the overall population.

Finally, multiple treatment inferences were controlled by administering the experiment only one time to each of the subjects.

Content Validity and Replicability. Content validity is concerned about whether the test instrument sufficiently covers, or measures, the variable of interest (Emory, 1991:180). Four levels of presentation modes were used in this experiment. By using multiple levels of intensity and a tabular format, adequate coverage of the fill pattern variable and its effect on perception, interpretation, and decision making were obtained. Additionally, pretesting of the instrument was accomplished using AFIT students and other colleagues and peers. During each pretest, subjects were asked to critique the instrument and to identify any questions, presentations or comments which were ambiguous or unclear. The process of incorporating the results of the various pretests significantly strengthens the experiments content validity.

Replicability is the degree to which other researchers can reproduce the experiment. The test instrument itself is contained in Appendix A. The underlying values used to create all presentations are contained in Appendix B (the end-of-exercise questionnaire is contained in Appendix C). In addition to using the same presentations and underlying data, anyone attempting to replicate this experiment would need to use the same measurement questions, time constraints, and so on. Certain aspects of the experiment, such as the specific classroom environment, may not be replicable. However, similar environments are plentiful and should not cause major deviations from one research finding to another. Reliability of this instrument is unknown due to the fact that it has not been tested to date.

Sample Population. The general population is considered to be mid to upper level managers of civilian or defense organizations. The sample population consists of AFIT PCE, and full-time students. These subjects were deemed appropriate in most respects because, although they are students, they are also managers to varying degrees and at varying levels. No effort will be made to isolate specific classes for the experiment. As a result, a much broader spectrum of backgrounds, skills, managerial levels, competencies, and so on will be captured in the sample population. Nonetheless, the sample population represents a convenience sample. This form of sampling is not as desirable as other sampling techniques (Emory, 1991:274). Furthermore, sampling subjects by PCE class were conducted based on availability and classroom schedules. These factors represent significant limitations within the sampling scheme. However, many of these concerns are considered minimal

in light of the broad spectrum of managers found within various PCE courses. Therefore, it is believed that the use of these subjects still comes close to matching the target population.

A comparison between key demographics of the sample population and United States Air Force (USAF) is found in Tables 16a and 16b. The USAF is a much larger subsection of the true population of all DoD and civilian managers and is more representative of that population. Tables 16a and 16b show that the sample demographics are quite similar to most of those of the USAF as reported by the Air Force Military Personnel Center (AFMPC). Although no O-1 information is available for the USAF, the relatively small number of O-1's (3) in the sample does not significantly hinder comparisons. Only a weighted average for the number of years of federal employment was available for USAF civilian employees. However, the averages were very comparable with a value of 17.8 years for the sample and 17 for the USAF. Table 16c shows the overall percentage of military and civilian managers. (AFMPC, 1993).

Table 16a. Comparative Military Demographics (AFMPC, 1993).

	Sample		USAF	
Demographic Factor	Frequency	% of Total	Frequency	% of Total
Years of Service				
0-5	20	20.2	23,920	28.2
6-10	28	28.3	21,982	26.0
11-15	27	27.3	18,371	21.7
16-20	17	17.2	12,254	14.5
21-25	5	5.1	6,350	7.4
26-30	2	2.0	1,812	2.1
Over 30	0	0.0	116	0.1

USAF computations are based on O-2 through O-10 figures.

Table 16a. Continued.

Demographic Factor	Sample Frequency	Sample % of Total	USAF Frequency	USAF % of Total
Gender				
Male	90	90.9	72,824	88.0
Female	9	9.1	12,140	12.0
Grade				
Enlisted	4	4.0	not avail	not avail
O-1	3	3.0	not avail	not avail
O-2	10	10.1	14,127	16.7
O-3	46	46.5	36,966	43.6
O-4	26	26.3	16,937	19.9
O-5	6	6.1	11,517	13.7
O-6	4	4.0	4,521	5.3
O-7 through O-10	0	0.0	302	0.4
Education				
Some College	3	3.0	0	0
Associates Degree	1	1.0	0	0
Baccalaureate	26	26.3	40,678	47.9
Some Graduate	23	23.2	not avail	not avail
Masters Degree	44	44.4	35,680	42.0
Doctoral Degree	2	2.0	8,606*	10.1*

* Includes professional degrees (i.e. Lawyer, Doctor, Dentist etc.)
USAF computations are based on O-2 through O-10 figures.

Table 16b. Comparative Civilian Demographics (AFMPC, 1993).

Demographic Factor	Sample Frequency	Sample % of Total	USAF Frequency	USAF % of Total
Years of Service				
0-5	5	6.0	not avail	not avail
6-10	15	18.1	not avail	not avail
11-15	14	16.9	not avail	not avail
16-20	17	20.5	not avail	not avail
21-25	16	19.3	not avail	not avail
26-30	10	12.0	not avail	not avail
Over 30	6	7.2	not avail	not avail
Weighted Average	17.8 Years		17 Years	

Table 16b. Continued.

Demographic Factor	Sample Frequency	Sample % of Total	USAF Frequency	USAF % of Total
Gender				
Male	58	69.9	38,400	72.0
Female	25	30.1	14,968	28.0
Grade				
Contractor	2	2.4	not avail	not avail
GG-13	1	1.2	not avail	not avail
GM-13	15	18.1	5,402	10.1
GM-14	5	6.0	2,933	5.5
GM-15	1	1.2	1,131	2.1
GS-09	1	1.2	not avail	not avail
GS-11	7	8.4	17,674	33.1
GS-12	39	47.0	20,658	38.7
GS-13	10	12.0	4,409	8.3
GS-14	2	2.4	968	1.8
GS-15	0	0.0	193	0.4
Education				
No HS Grad	0	0.0	79	0.1
High School Grad	2	2.4	5,680	10.6
Some College	10	12.0	9,007	16.9
Associates Degree	7	8.4	4,493	8.4
Baccalaureate	25	30.1	17,689	33.1
Some Graduate	13	15.7	4,089	7.8
Masters Degree	26	31.3	11,095	20.8
Doctoral Degree	0	0.0	1,230	2.3

Table 16c. Civilian and Military Personnel Percentages (AFMPC, 1993).

Demographic Factor	Sample Frequency	Sample % of Total	USAF Frequency	USAF % of Total
Military	99	54.4	84,964	61.4
Civilian	83	45.6	53,368	38.6

Construction of the Experiment

The experiment was designed using a paper and pen format. This format was chosen over other media because it provides greater research flexibility and ease of administration. Other media such as computers can induce reactive effects associated with the experimental setting.

Experimental subjects were randomly assigned to the various cells within the factorial experiment and paper copies of the experimental package were then handed to the subjects. The subjects recorded their responses to specific perception and decision type questions on the test instrument itself.

The subjects were told that they are playing the part of a loan officer and must decide whether to grant or deny a loan and specify a particular loan amount to a series of fictitious companies. Their decisions were based upon a presentation (either graphical or tabular) of the company's net assets for the current year.

Unlike prior experiments at AFIT, the presentations within each test packet were presented in a specific arrangement. The first presentation depicted net asset trends for the past four years for company A and contained questions that were used for gathering information on the dependent variable. The second presentation depicted net asset trends for company B for the past four years and also was used to gather information on the dependent variable. The third presentation represented company C and used the same format as company's A and B, but was used only to determine if the subjects were able to comprehend the decision rule required to grant a loan. Subjects were given two minutes to evaluate each company and answer two questions. The first questions

dealt with the subject's comprehension of the decision rule culminating with the final decision on whether to grant or deny a loan. The second question required a direct interpretation of loan criteria decision rule leading to the subject's determination of a specific amount to loan the company based on their perceptual interpretation of Mode of Presentation and Trend that represents the company's net asset information.

Each page of the experiment contained one presentation and two questions concerning the three fictitious companies. Although a time limit of two minutes was imposed, students were allowed to review each presentation as often as they wanted in order to answer the questions in the end-of-exercise questionnaire.

A loan granting decision rule was used to help guide the experimental subjects in terms of the types of issues a loan officer should be concerned about. The loan decision rule was specific enough to ensure a basic understanding of the procedure, but not specific enough to make the decision for the experimental subject. In other words, the subjects were required to perform some interpretation of the presentations of the various companies.

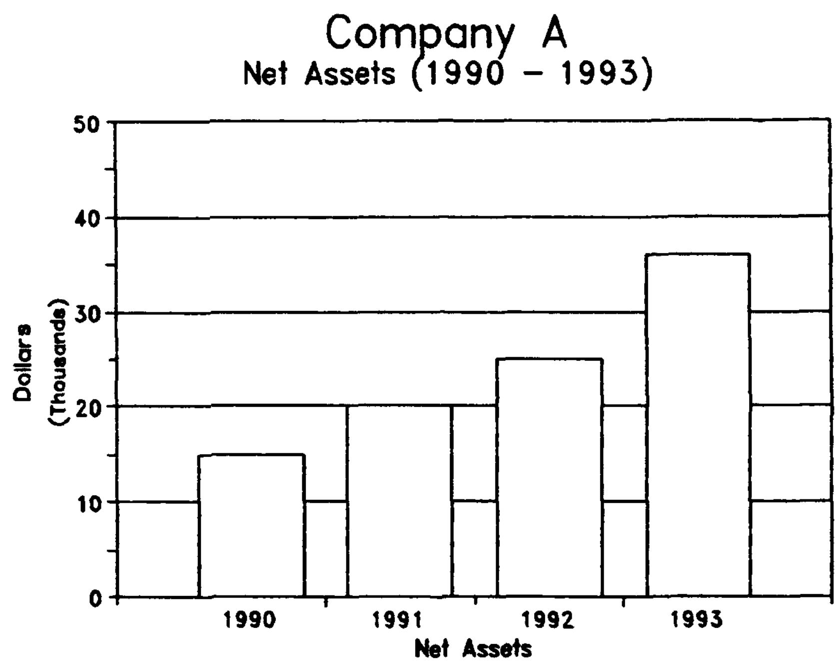
Ten perceptual questions were asked in the end-of-exercise questionnaire to measure the subject's interpretation of general perceptual trends contained within specific presentations. A seven-point Likert scale was used with anchors of very significant and very insignificant on either end of the scale. The use of these anchors was deemed appropriate due to prior research by Barber and Dunn (Barber and Dunn, 1992:43).

All graphical presentations were constructed using high integrity criteria discussed in Chapter II, Literature Review. Only vertical bar charts were used in the graphical presentations to eliminate the potential for confounding variables to enter into the experiment. The Mode of Presentation was identical in all respects except for the use of fill patterns or tabular data within each experimental treatment group. An example of a series of presentations used in the experiment and their associated questions are shown in Figures 10 through 12.

Conducting the Experiment

Pretesting has proven invaluable in fine tuning experiments and test packages of previous research efforts (Barber and Dunn, 1992:40). Therefore, thorough pretesting of the experimental package was conducted.

One hundred and eighty experimental packages comprised of 15 replications (r) of the twelve treatment combinations of the experimental variables were randomly arranged prior to administering the experiment to the subjects. Based on the number of subjects to be tested, the experimental packages were selected from the random arrangement and distributed accordingly to the subjects being tested. The subjects were instructed not to open the package until told to do so. This allowed all subjects to receive the package prior to the start of the timed experiment. Once all subjects had been given a test, they were asked to read the instructions comprising a total of four pages and stop at the point indicated at the end of the instructions. At this point, any questions pertaining to the experiment were addressed by the

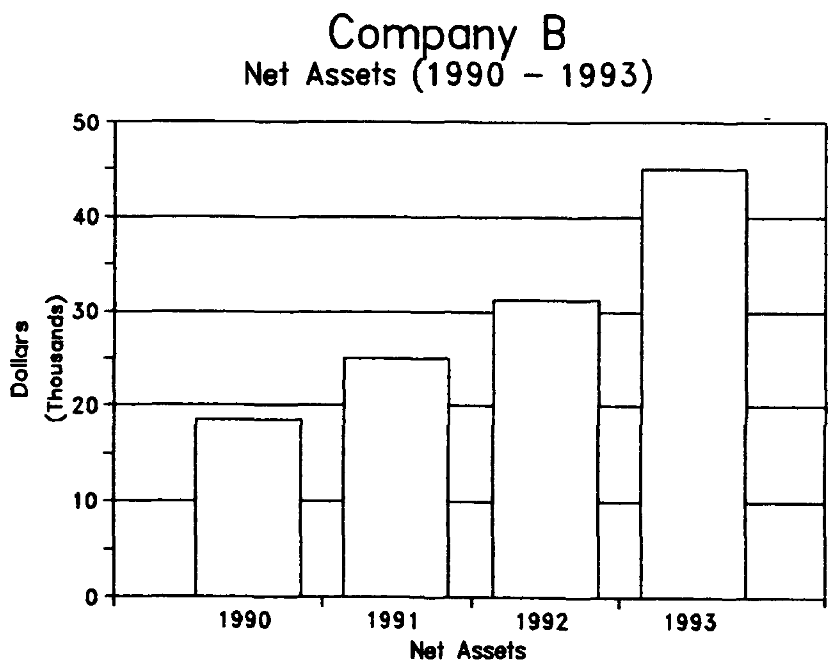


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________ (Fill in Amount)

(Do not turn the page until told to do so by the Monitor)

Figure 10. Company A - No Fill Pattern and Increasing Trend - Graph 1.

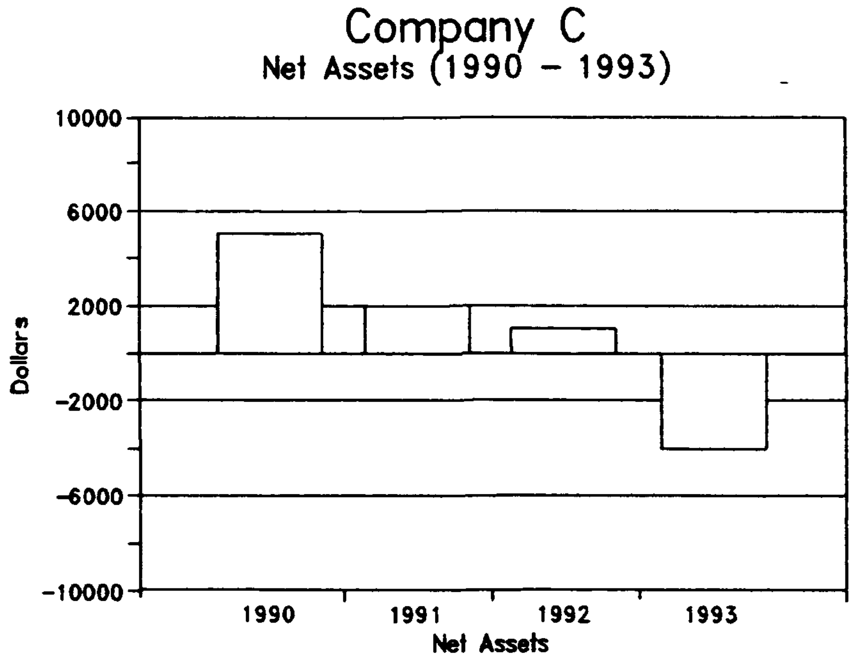


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________ (Fill in Amount)

(Do not turn the page until told to do so by the Monitor)

Figure 11. Company B - No Fill Pattern and Increasing Trend - Graph 2.



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________ (Fill in Amount)

(Do not turn the page until told to do so by the Monitor)

Figure 12. Company C - No Fill Pattern and No Trend - Graph 3.

test proctor. Subjects were told that no questions would be answered during the test. This helped maintain consistency between various administrations of the test. The cover sheet explains the business scenario used within the test instrument and define the criteria used for making the final decision as to whether to approve or disapprove the loan to the fictitious company. The remaining pages of the instructions explained the decision rule to be used by the subjects in determining the amount of the loan to grant each fictitious company. Also included in the instructions were definitions of basic accounting terminology to clearly state terms used in the experiment. Subjects were not allowed to use any device other than the test itself to determine graphical measurements or loan amounts. Additionally, the subjects were briefed that there were no right or wrong answers. No mention was made on the Mode of Presentation used. This eliminated any bias concerning the Mode of Presentation within the test.

End-of-Exercise Questionnaire

An end-of-exercise questionnaire was attached at the end of the experimental package. The reasoning behind this questionnaire is based on findings in previous research that some perceptual and demographic characteristics are significant in graphical presentation preferences and interpretation (Carvalho and McMillan, 1992:54; Barber and Dunn, 1992:68). The questionnaire allowed for a more thorough analysis of the experimental findings to evaluate if perceptual interpretations and demographics characteristics were correlated to decision making. Appendix C contains the end-of-exercise questionnaire.

The first ten questions contained in the end-of-exercise questionnaire were designed to obtain and compare trends related to the subject's perceptual interpretation of the confidence, risk, and significance of each fictitious company's trend. Specifically, these ten questions were used to test hypotheses concerning the relationship of perceptual interpretations and their influence, or lack of, on decision making. The first seven questions in the questionnaire were asked using a seven-point Likert scale anchored with well defined incremental levels ranging from strongly disagree to strongly agree. Question one was design to measure the experimental subject's confidence in their application of the loan criteria, decision to approve or disapprove a loan, and amount they loaned to each company. Questions two through four were design to measure the experimental subject's perceptual interpretation of the degree of risk they associated to each fictitious company. Questions five through seven were designed to determine the degree of significance the experimental subject's associated to the trends of each fictitious company. Questions eight through ten used a well defined five-point Likert scale to measure the experimental subject's interpretation of the confidence they associated with their loan evaluation of each fictitious company. A five-point Likert scale was used over the seven point scale in questions eight through ten because the range requirements used to define the subject's level of confidence could be better defined on a five-point scale.

Questions 11 through 13 and question 22 were included in the questionnaire to provide input for modification of the test instrument during the pretesting and were included again with the final instrument

to provide continuing face validity to the test instrument during the study.

Demographic information was requested in questions 14 through 21 to be used if the results suggested the possibility of a relationship between the demographic characteristics and perceptual interpretations of the presentations. The subject's sex has been found to be a significant factor in graphical interpretation in the past and was included in the questionnaire. The rank of the subject was also important because it signified the level of management. As a manager moves up in an organization's hierarchy, one might expect the complexity of their job to increase. With this added complexity, managers may make use of additional tools to save time such as graphical displays and/or summaries. Additionally, it was important to know how often the subjects work with graphics. Working with graphics can include reading or constructing graphics. Ives suggests that people can better interpret information within graphics that they are used to (Ives, 1982:21). This familiarity with graphics is important in terms of the subject's accuracy and speed of interpretation of graphical displays. Whether the subject ever uses graphs to make decisions is of central importance to this research. As a result, this question was also included in the questionnaire. Subjects who routinely make decisions with the aid of graphical displays may have predisposed ideas as to what a significant trend is and may tend to make quicker, more concrete decisions concerning the graph.

All variable terms and statistical data for this research is contained in Appendix D through Appendix H.

Conclusion

Presentations using graphs with varying intensities of fill patterns and tabular presentations versus presentations without fill patterns were tested to determine if there is any difference in terms of perception, interpretation, and decision making. By comparing graphical presentations which are identical in all respects other than fill patterns, the use of a factorial experimental design was deemed appropriate. The analysis of this experiment uses a Multifactor ANOVA "F" statistic to test for differences between the experimental treatment means. Finally, a one-way ANOVA was used to determine any correlations between perceptual and demographic characteristics and presentation mode interpretation and decision making.

IV. Analysis and Findings

A factorial experimental design using 12 different experimental treatment combinations was used in this experiment. The 12 treatment groups consisting of various combinations of the factors Trend and Mode of Presentation were used to test four separate five part hypotheses. In addition, a fifth hypothesis concerning differences in gender bias was investigated. This chapter presents the data obtained from the research and an analysis of the experimental results and findings. The chapter will also present additional analyses based on findings unrelated to the experimental hypotheses that may provide help for future research in this topical area.

Experimental Results

Appendices E - H contain the overall results of all the experimental data. Appendix D contains a description of the terms and abbreviations used in the Statgraphics output tables. Appendix D also describes the variables used in the experiment. Because the experimental data were collected from 12 unique treatment combinations (group composition is discussed in Chapter III), the first step in analysis of the data was to run a multi-factor ANOVA and multiple range tests on the dependent response variables. These statistical procedures were accomplished to determine if the experimental variables of Trend and Mode of Presentation affected the response variables to any degree. An ANOVA on the main and interactive effects of both experimental variables, as well as a multiple range test were calculated to determine

if any statistical differences existed among the 12 treatment combinations.

There were six main tests conducted in the analysis of the experiment. Test 1 was conducted to compare treatment means versus demographic data to determine if a difference in mean responses could be attributed to demographic characteristics. Five separate tests were conducted on the factorial experiment involving the factors Trend and Mode of Presentation on several perceptual and decision making response variables. The first test associated with the factorial experiment, Test 2, is a test of treatment means associated with the factors Trend and Mode of Presentation. This test is followed by Test 3, a test for factor interaction between Trend and Mode of Presentation. The last two tests, Test 4 and Test 5, conducted in the factorial experiment, were tests for the main effects associated with the factors Trend and Mode of Presentation. The following paragraphs describe each of the above tests and their associated hypotheses.

Test 1. Test for treatment means of demographic characteristics. The experimental hypothesis for Test 1 was:

(1) H_0: $\mu_1 = \mu_2 = \ldots = \mu_p$ There is no difference among treatment means associated with the demographic characteristics of the respondents.

H_a: At least two treatment means differ.

This test was conducted on demographic characteristics only. A one-way ANOVA was used to test the null hypothesis.

Test 2. Test for treatment means associated with the factor Trend. The experimental hypotheses for Test 2 were:

(2a) H_0: No difference exists among the factor Trend treatment means as they relate to loan decisions made.

H_a: At least two treatment means differ.

(2b) H_0: No difference exists among the factor Trend treatment means as they relate to the respondents confidence in application of loan approval criteria.

H_a: At least two treatment means differ.

(2c) H_0: No difference exists among the factor Trend treatment means as they relate to the respondents perception of the significance associated with Trend.

H_a: At least two treatment means differ.

(2d) H_0: No difference exists among the factor Trend treatment means as they relate to the respondents perception of risk associated with their loan decision.

H_a: At least two treatment means differ.

(2e) H_0: No difference exists among the factor Trend treatment means as they relate to confidence in decision making.

H_a: At least two treatment means differ.

This test was conducted on the factorial experiment only. Multiple range analysis was used to test the null hypotheses.

Test 3. Test for treatment means associated with the factor Mode of Presentation. The experimental hypotheses for Test 3 were:

(3a) H_0: No difference exists among the factor Mode of Presentation treatment means as they relate to loan decisions made.

H_a: At least two treatment means differ.

(3b) H_0: No difference exists among the factor Mode of Presentation treatment means as they relate to the respondents confidence in application of loan approval criteria.

H_a: At least two treatment means differ.

(3c) H_0: No difference exists among the factor Mode of Presentation treatment means as they relate to the respondents perception of the significance associated with Trend.

H_a: At least two treatment means differ.

(3d) H_0: No difference exists among the factor Mode of Presentation treatment means as they relate to the respondents perception of risk associated with their loan decision.

H_a: At least two treatment means differ.

(3e) H_0: No difference exists among the factor Mode of Presentation treatment means as they relate to confidence in decision making.

H_a: At least two treatment means differ.

This test was conducted on the factorial experiment only. Multiple range analysis was used to test the null hypotheses.

Test 4. Test for Trend and Mode of Presentation factor interaction. The experimental hypotheses for Test 4 were:

(4a) H_0: The factors Trend and Mode of Presentation don't interact to affect response means as they relate to loan decisions made.

H_a: At least two treatment means differ.

(4b) H_0: The factors Trend and Mode of Presentation don't interact to affect response means as they relate to respondents confidence in application of the loan approval criteria.

H_a: At least two treatment means differ.

(4c) H_0: The factors Trend and Mode of Presentation don't interact to affect response means as they relate to the respondents perception of the significance associated with Trend.

H_a: At least two treatment means differ.

(4d) H_0: The factors Trend and Mode of Presentation don't interact to affect response means as they relate to the respondents perception of risk associated with their loan decision.

H_a: At least two treatment means differ.

(4e) H_0: The factors Trend and Mode of Presentation don't interact to affect response means as they relate to confidence in decision making.

H_a: At least two treatment means differ.

This test was conducted on the factorial experiment only. Multiple range analysis was used to test the null hypotheses.

<u>Test 5.</u> Test for main effects of the factor Trend. The experimental hypotheses for Test 5 were:

(5a) H_0: No difference exists between the (t) mean levels of factor Trend as they relate to loan decisions made.

H_a: At least two treatment means differ.

(5b) H_0: No difference exists between the (t) mean levels of factor Trend as they relate to the respondents confidence in application of loan approval criteria.

H_a: At least two treatment means differ.

(5c) H_0: No difference exists between the (t) mean levels of factor Trend as they relate to the respondents perception of the significance associated with Trend.

H_a: At least two treatment means differ.

(5d) H_0: No difference exists between the (t) mean levels of factor Trend as they relate to the respondents perception of risk associated with their loan decision.

H_a: At least two treatment means differ.

(5e) H_0: No difference exists between the (t) mean levels of factor Trend as they relate to confidence in decision making.

H_a: At least two treatment means differ.

This test was conducted on the factorial experiment only. Multiple range analysis was used to test the null hypotheses.

Test 6. Test for main effects of the factor Mode of Presentation. The experimental hypotheses for Test 6 were:

(6a) H_0: No difference exists between the (m) mean levels of factor Mode of Presentation as they relate to loan decisions made.

H_a: At least two treatment means differ.

(6b) H_0: No difference exists between the (m) mean levels of factor Mode of Presentation as they relate to the respondents confidence in application of loan approval criteria.

H_a: At least two treatment means differ.

(6c) H_0: No difference exists between the (m) mean levels of factor Mode of Presentation as they relate to the respondents perception of the significance associated with Trend.

H_a: At least two treatment means differ.

(6d) H_0: No difference exists between the (m) mean levels of factor Mode of Presentation as they relate to the respondents perception of risk associated with their loan decision.

H_a: At least two treatment means differ.

(6e) H_0: No difference exists between the (m) mean levels of factor Mode of presentation as they relate to confidence in decision making.

H_a: At least two treatment means differ.

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significance levels of .2554 for Mode of Presentation (hypothesis 6a) and .6639 respectively for the interaction effects of Trend and Mode of Presentation (hypothesis 4a) indicated that there were no statistical differences attributed to the main interactive effects on the response variable of loan amount for Company A, thus supporting the null hypotheses in both cases. Results are shown in Table 17.

Table 17. ANOVA of Company A Loan Responses.

Factor	p-value for Company A
Trend	.0001*
Mode	.2554
Interaction	.6639

* denotes a statistically significant difference

In conducting a multiple range analysis of the response variable loan amount for Company A on the experimental variable of Trend to test hypothesis 2a, analysis of the results, displayed in Table 18, show that trend did cause a significant difference in loan amounts for Company A. The multiple range analysis shows that although the differences in loan amounts given between presentations that had increasing and no trend were not statistically significant at the α = .05 confidence level, differences between loan amounts given for increasing to decreasing trends had an effect on the decision as to the amount of the loan given to Company A. This difference between the groups was statistically significant at the α = .05 level.

Table 18. Multiple Range Analysis For Company A Loan Amounts by TREND.

Level*	Count	LS Mean	Homogeneous Groups
C	60	52367.400	X
A	60	57333.717	X
B	62	57587.587	X

contrast	difference	+/- limits	
A - B	-253.871	2540.46	
A - C	4966.32	2559.35	**
B - C	5220.19	2540.46	**

* denotes levels of factor Trend (A = Increasing, B = no change, C = decreasing)
** denotes a statistically significant difference.

The multiple range analysis for Mode of Presentation to test hypothesis 3a is contained in Table 19. This analysis shows that the only statistically significant difference derived among the four levels contained in the experimental variable Mode of Presentation shows up in a contrast between vertical bar graphs containing no fill patterns and vertical bar graphs containing heavy fill patterns. In contrasting the rest of the levels of the factor, there were no statistical differences between treatment means.

The experimental results for Company B are contained in Table 20. Again, multi-factor ANOVA and multiple range analysis statistical procedures were used to interpret the data. In the multi-factor ANOVA to test the difference of the means of the 12 treatment groups for Company B, a p-value of .0000 was obtained for the main effect of the factor Trend in the experimental model. As with Company A, this value indicates that there is a statistical difference attributable to the main effect of trend on the experimental groups decision of what loan

Table 19. Multiple Range Analysis For Company A Loan Amounts by Mode of Presentation.

Level*	Count	LS Mean	Homogeneous Groups
1	45	54333.889	X
4	47	55561.272	XX
2	45	55822.689	XX
3	45	57333.756	X

contrast	difference	+/- limits	
1 - 2	-1488.80	2955.28	
1 - 3	-2999.87	2955.28	**
1 - 4	-1227.38	2926.17	
2 - 3	-1511.07	2955.28	
2 - 4	261.417	2926.17	
3 - 4	1772.48	2926.17	

* denotes levels of factor Mode of Presentation (1 = no fill pattern, 2 = light fill pattern, 3 = heavy fill pattern, 4 = tabular)
** denotes a statistically significant difference.

amount to give Company B and provides evidence to support hypothesis 5a. The p-value of .6992 for the main effect of the factor Mode of Presentation also is consistent with the results obtained in Company A and, again, provides evidence to support hypothesis 6a that the main effect of the factor causes no statistical difference between the mean responses for the 12 treatment combinations. Additionally, as was the case with Company A, the p-value for the interactive effects of the two factors is statistically insignificant (p-value = .3089), and lends credence to support of null hypothesis 4a that the difference between mean responses caused by a factor (Mode of Presentation/Trend) interaction is not statistically significant.

The multiple range analysis of the factor Trend, Table 21, backs up the findings shown in the multi-factor ANOVA for the results of the dependent variable for Company B. In making contrasts among the three

Table 20. ANOVA of Company B Loan Responses.

Factor	p-value for Company A
Trend	.0000*
Mode	.6992
Interaction	.3089

* denotes a statistically significant difference

levels of the factor Trend, a statistical difference between treatment means appears in contrasting the means of treatment groups that had an increasing trend of net assets and those that had no change in the trend of net assets. Also, a statistical difference was found between the treatment groups that had a no change trend and decreasing trend for net assets. Although the results of the multiple range analysis of trend for Company A and B differ slightly, the analysis provides additional evidence that null hypothesis 2a should be rejected.

Table 21. Multiple Range Analysis For Company B Loan Amounts by TREND.

Level	Count	LS Mean	Homogeneous Groups	
B	62	55057.554	X	
C	60	60583.550		X
A	60	62050.150		X

contrast	difference	+/- limits
A - B	6992.60	2732.79 *
A - C	1466.60	2753.11
B - C	-5526.00	2732.79 *

* denotes a statistically significant difference.

The multiple range analysis of the factor Mode of Presentation is also contained in Table 22. Again, the analysis provides evidence that the null hypothesis 3a should be accepted. The results of the test show that no statistical difference exists between any of the mean responses for the four levels of the dependent variable factors for Company B.

Table 22. Multiple Range Analysis For Company B Loan Amounts by Mode of Presentation.

Level	Count	LS Mean	Homogeneous Groups
1	45	58624.800	X
2	45	58911.400	X
4	47	59007.494	X
3	45	60377.978	X

contrast	difference	+/- limits
1 - 2	-286.600	3179.02
1 - 3	-1753.18	3179.02
1 - 4	-382.694	3147.70
2 - 3	-1466.58	3179.02
2 - 4	-96.0941	3147.70
3 - 4	1370.48	3147.70

* denotes a statistically significant difference.

Several more multi-factor ANOVA's and multiple range tests were calculated to analyze the effects of the experimental variables on experimental subject's perceptions to determine if any correlation exists between perceptions and decision making. Ten perceptual questions contained in the end-of-exercise questionnaire were tested using the same procedures listed above to determine the effects of the experimental design on the responses of the experimental subjects. The following paragraphs report the findings for each question in the order they were presented to the experimental subjects.

Question one was used to determine the experimental subject's perception of confidence in their application of the loan approval criteria used in the experiment. The results of the multi-factor ANOVA and multiple range test for question one are contained in Tables 48 - 50 of Appendix G. The multi-factor ANOVA shows that the main effects of Trend, Mode of Presentation, as well as any interactive effects of the two factors didn't have any statistically significant effect on the mean responses to this question. All of the p-values (.8043, .4851, and .5558) respectively for the model were statistically insignificant. This analysis provides support for acceptance of null hypotheses 5b, 6b, and 4b. The multiple range analysis supports the multi-factor ANOVA findings. For both factors there are no significant differences found in contrasting the mean responses among the various levels of each factor. On the basis of these results, the null hypotheses for 2b, and 3b would be accepted.

Questions two, three, and four were used to test the experimental subject's perception of risk associated with the loan decisions they made for each of the fictitious companies. The results of the ANOVA and multiple range tests for questions two through four are contained in Table 23. Table 23 contains the collective results of the ANOVA's for each response.

As displayed in Table 23, Trend had a statistically significant effect on the mean responses to questions two and three, thus providing support for rejecting null hypothesis 5c. However, Trend was statistically insignificant as a factor in question four. As mentioned in Chapter III, Company C was used to determine if the experimental

Table 23. ANOVA For Questions 2 - 4 Risk Data.

Factor	p-value for Company A	p-value for Company B	p-value for Company C
Trend	.0000*	.0004*	.2192
Mode	.4209	.1246	.5639
Interaction	.3529	.6947	.7105

* denotes a statistically significant difference

subjects understood and could correctly apply the loan criteria and loan decision rule. The presentation was purposely constructed to violate the loan approval criteria. Therefore, we would expect such results for Company C and still reject the null hypothesis 5c.

The main effect of the Mode of Presentation and the interaction effects of both factors were statistically insignificant on the mean responses to questions two, three, and four. These results give support to the acceptance of null hypotheses 6c and 4c. In conducting multiple range analysis of the three questions, Trend again provided statistically significant contrasts between mean responses for the three levels and provides support for the rejection of null hypothesis 2c. The multiple range analysis for Mode of Presentation showed only one statistically significant difference in contrasting response means. This significant difference occurred in question three in contrasting the differences between mean responses for vertical bars with light fill patterns with that of data presented in a tabular format. Therefore, the null hypothesis for 3c is rejected for this contrast only and accepted for questions two and four.

Questions five through seven were used to test the perceptions of the experimental subjects as to the significance they associated to the trend of net assets for each fictitious company. The results of the multi-factor ANOVA and multiple range tests for questions five through seven are contained in Table 24. Again, Table 24 contains the collective results of the p-values for questions five through seven.

Table 24. ANOVA For Questions 5 - 7 Trend Significance Data.

Factor	p-value for Company A	p-value for Company B	p-value for Company C
Trend	.0000*	.0000*	.0104*
Mode	.9649	.6776	.2639
Interaction	.8722	.9526	.4430

* denotes a statistically significant difference

As can be seen from the results of Table 24, the main effects of Trend proved to be significant in every case. All the p-values that denotes the level of significance the main effect of Trend had on the mean responses for each question are all statistically significant. Therefore, these results provide strong evidence that null hypothesis 5d should be rejected. The p-values for the main effect of the Mode of Presentation and interaction effects of the two factors are all statistically insignificant in all three questions and provide support for the acceptance of null hypotheses 6d and 4d. The multiple range analysis of Trend shows that statistically significant differences exist in the contrast of the levels and their associated response means. This leads to the rejection of null hypothesis 2d. The multiple range test

conducted on the Mode of Presentation for all levels shows no statistical difference among any of the levels in each question and supports acceptance of null hypothesis 3d.

Questions eight through ten were used to again determine the experimental subject's perceptions of confidence in their loan decision made. However, in this case their perceptions of confidence were linked to their loan decisions made for each fictitious company. The results of the ANOVA and multiple range tests for questions eight through ten are contained in Table 25. Table 25 contains the collective results of the p-values for each question.

Table 25. ANOVA For Questions 8 - 10 Confidence of Loan Evaluation.

Factor	p-value for Company A	p-value for Company B	p-value for Company C
Trend	.0887	.0346*	.1046
Mode	.8137	.9845	.4093
Interaction	.8683	.9010	.4788

* denotes a statistically significant difference

Unlike previous results, the p-values representative of the main effects of Trend for two of three of these questions are statistically insignificant. Only question nine had a statistical significant difference attached to the main effects of Trend. These results are similar to the findings in question one and support acceptance of null hypothesis 5e. All the p-values for the main effect of Mode of Presentation and the interactive effects of the two factors are statistically insignificant and support acceptance of null hypotheses 6e

and 4e. The multiple range test in questions eight and nine both show the contrast between the response means associated with the increasing and no trend levels of the factor Trend to be statistically significant. These findings support for the rejection of null hypothesis 2e. The multiple range test conducted on the Mode of Presentation for each question supports the conclusion that no difference exists between the various treatment levels. This provides support for acceptance of null hypothesis 3e.

Demographic Information

The experimental subjects were asked to indicate demographic characteristics in questions 14, 15, and 17-21 in the end-of-exercise questionnaire. One-way ANOVA's and descriptive statistics were calculated on the questions to gain understanding of the demographic characteristics of the data collected.

The experimental subjects were asked to indicate the following demographic characteristics: (a) how often they use graphics in decision making, (b) how often they construct graphs for presentations, (c) their rank or grade, (d) number of years of federal employment, (e) gender, (f) educational background, (g) and professional experience. The first step in analysis of the demographic data was to conduct a one-way ANOVA on the response variables to determine if there were any statistically significant differences noted between specific demographic characteristics. Individual designations in each question were used as categorical values and the data collected from the experimental subjects was used as the dependent variable under analysis. The results of the ANOVA tests on questions 14, 15, and 17-21 are contained in Table 26.

Table 26. ANOVA of Demographic Data - Questions 14, 15, and 17 - 21.

Factor	p-value for Company A	p-value for Company B
Graph Use	.7550	.2287
Graph Construction	.0652	.9899
Rank or Grade	.1036	.2154
Federal Employment	.7820	.7509
Gender	.0313*	.4788
Education Level	.2873	.3421
Professional Experience	.4733	.7895

* denotes a statistically significant difference

After the ANOVA's were conducted on the demographic characteristics, descriptive statistics were calculated. The next several paragraphs discuss this information.

Fourteen (less than 8%) of the one-hundred eighty-two subjects had never before used graphics in decision making which represented the smallest relative frequency in the group of experimental subjects. Thirty-one people used graphs in decision making at least once per year. Fifty-one people used graphs in decision making at least once a month which represented the largest relative frequency of the group. The remaining distributions can be seen in Table 27.

Table 27. Frequency Tabulation For Graph Use.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	1	14	.0769	14	.0769
2	2	31	.1703	45	.2473
3	3	51	.2802	96	.5275
4	4	26	.1429	122	.6703
5	5	30	.1648	152	.8352
6	6	13	.0714	165	.9066
7	7	17	.0934	182	1.0000

Over 34% of the experimental subjects reported constructing graphs for presentations at least once per month. Less than 10% reported never constructing graphs for presentations. The remaining distributions can be seen in Table 28.

Table 28. Frequency Tabulation For Graph Construction.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	Never	18	.0989	18	.0989
2	Once a year	37	.2033	55	.3022
3	At least once a month	62	.3407	117	.6429
4	At least twice a month	19	.1044	136	.7473
5	At least once a week	33	.1813	169	.9286
6	Every other day	8	.0440	177	.9725
7	Daily	5	.0275	182	1.0000

The average rank for military members taking the experiment was the rank of captain. Over 25% of all subjects were captains. The average grade for DoD civilians was the grade of GS-12. GS-12's

represented over 21% of all subjects tested. The lowest military grade tested was one E-4. The highest military grade tested were four O-6's. The lowest civilian grade tested was one GS-09. The highest civilian grade tested was one GM-15. Overall, the demographic results pertaining to rank are very representative of the target population. The remaining distributions can be seen in Table 29.

Table 29. Rank and Grade Frequency Tabulation.

Lower Class	Limit	Relative Frequency	Cumulative Frequency	Cum. Frequency	Rel. Frequency
1	CONTRACT	2	.01099	2	.0110
2	E-4	1	.00549	3	.0165
3	E-5	1	.00549	4	.0220
4	E-7	2	.01099	6	.0330
5	GG-13	1	.00549	7	.0385
6	GM-13	15	.08242	22	.1209
7	GM-14	5	.02747	27	.1484
8	GM-15	1	.00549	28	.1538
9	GS-09	1	.00549	29	.1593
10	GS-11	7	.03846	36	.1978
11	GS-12	39	.21429	75	.4121
12	GS-13	10	.05495	85	.4670
13	GS-14	2	.01099	87	.4780
14	O-1	3	.01648	90	.4945
15	O-2	10	.05495	100	.5495
16	O-3	46	.25275	146	.8022
17	O-4	26	.14286	172	.9451
18	O-5	6	.03297	178	.9780
19	O-6	4	.02198	182	1.0000

Forty-two of the subjects had from six to ten years of federal service. Forty-one of the subjects had from eleven to fifteen years of federal service. Most of the subjects had between six and twenty years of federal employment. This demonstrated representative characteristics of the target population of mid to upper level DoD managers. The remaining distributions can be seen in Table 30.

Table 30. Years of Federal Service Frequency Tabulation.

Class	Lower Limit	Relative Frequency	Cumulative Frequency	Cum. Frequency	Rel. Frequency
1	0 to 5	25	.1374	25	.137
2	6 to 10	43	.2363	68	.374
3	11 to 15	41	.2253	109	.599
4	16 to 20	34	.1868	143	.786
5	21 to 25	21	.1154	164	.901
6	26 to 30	12	.0659	176	.967
7	over 30	6	.0330	182	1.000

The experiment contained 182 subjects of which 34 were female and 148 were male. Demographic analysis indicated that there were differences between the mean responses based on sex for responses to Company A only. In this instance, women tended to be less conservative in the value of loans given to the fictitious Company A than men. However, Company B's results contradicted the results found for Company A. Therefore, there is not sufficient evidence to justify a rejection of null hypothesis six. The ANOVA's and descriptive statistics are listed in Tables 31 and 32.

Table 31. Gender One-Way Analysis of Variance For Company A and B Loan Amounts.

Source of Variation	p-value for Company A	p-value for Company B
Between Groups	.0313*	.4788

* denotes a statistically significant difference

Over 38% of the subjects had obtained a masters degree. Over 28% had at least a bachelor's degree. This tends to be very representative of the target population. Most of the subjects (over 37%) reported

Table 32. Gender Frequency Tabulation.

Class	Lower Limit	Relative Frequency	Cumulative Frequency	Cum. Frequency	Rel. Frequency
1	Female	34	.187	34	.187
2	Male	148	.813	182	1.000

their primary basis for professional experience to be that of managers. Again, this is very representative of the target population of interest. The remaining distributions can be seen in Table 33 and Table 34.

Table 33. Education Frequency Tabulation.

Class	Lower Limit	Relative Frequency	Cumulative Frequency	Cum. Frequency	Rel. Frequency
1	High School Graduate	2	.0110	2	.0110
2	Some College	13	.0714	15	.0824
3	Associate Degree	8	.0440	23	.1264
4	Bachelors Degree	51	.2802	74	.4066
5	Some Grad Courses	36	.1978	110	.6044
6	Masters Degree	70	.3846	180	.9890
7	Doctoral Degree	2	.0110	182	1.0000

Debriefing Questions

Debriefing questions were asked in questions 11-13, 16, and 22 to help provide continuing support regarding the validity of the experimental task. The experimental subjects were asked if the instructions were clear and simple to follow, and, if not, to indicate weaknesses or suggest means of improvement. They were also asked to

Table 34. Professional Experience Frequency Tabulation.

Class	Lower Limit	Relative Frequency	Cumulative Frequency	Cum. Frequency	Rel. Frequency
1	Technical	23	.1264	23	.126
2	Contracts	23	.1264	46	.253
3	Support	26	.1429	72	.396
4	Managerial	68	.3736	140	.769
5	Engineering	16	.0879	156	.857
6	Other	10	.054	166	.912
7	Scientific	3	.0165	169	.929
8	Operations	13	.0714	182	1.000

indicate the amount of time required by, their interest in, and knowledge of the experimental task. Finally, the experimental subjects were asked to provide any additional comments concerning the experiment or end-of-exercise questionnaire on the back of the experiment.

Only four (2%) of the one-hundred and eighty-two subjects stated that the instructions were not simple to follow, and, in all four cases, the main problem the subjects had with the instructions was that the loan criteria and instructions were too simple to make a decision on the fictitious company's loans. Table 35 shows the frequency breakout for the those who found the experimental package instructions difficult.

Table 35. Instruction Difficulty Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	No	4	.0220	4	.0220
2	Yes	178	.9780	182	1.0000

The subjects were given two minutes per company to make their loan decision. The subjects were told prior to initiation of the experiment

that the entire test would take less than 15 minutes. On average, it took the experimental subjects 1.82 minutes to make their loan determinations for all three companies. The most frequently listed time to complete the loan decisions for all three companies was one minute.

The average level of interest experienced by the entire group of participants was slightly above a moderate level of interest. On a scale of one to seven the most frequently circled interest level was four. The average interest level was 4.3.

None of the experimental subjects had previous knowledge of the experimental task. In addition, only two people made comments concerning suggested improvements to the experiment on the back of the test. Again, as with question 11, the subjects stated that the experimental task was too simple and recommended a more rigorous decision rule be applied to make loan determinations for the companies.

Experimental Issues

There were many problems encountered in the construction and administration of this experiment. Many of the problems with the test instrument were cleared up during pretesting of the test instrument. However, several problems were encountered even after the instrument was pretested. One of the main problems that had to be resolved early on was confusion on the part of the experimental subjects as to what constituted a no trend presentation. This confusion led to several of the subjects applying the wrong decision rule for determination of loan amounts for the fictitious companies. In these cases, the subjects would either interpret presentations with no trends as either decreasing or increasing rather than presentations representing no trend in net

asset. By thoroughly explaining the decision rule to each experimental group, this problem was resolved early enough to ensure the experimental results were not biased.

Construction and statistical analysis of the test instrument also presented many challenges. No other thesis teams at AFIT had attempted to conduct an experiment testing graphical displays using a factorial experimental design. There are many issues related to the design of this type of experiment that must be thoroughly understood before an experiment can be successfully carried out. One text book on experimental design was particularly useful in the development and analysis of this research. The book, Statistical Principles in Experimental Design, Second Edition, by B.J. Winer (1971), was used extensively in the design and analysis of this experiment.

V. Conclusion

The use of graphics in decision making have become increasingly more common not only within the DoD, but also in today's media. The proliferation of software packages has made the use of graphical presentations in all facets of decision making more widespread. This has made the relevance of this research even more timely due to the fact that chances are very good that DoD managers may have to use graphics as decision making aids either in their personal or professional life.

Summary of Results

A review of the literature showed that there are numerous standards which have been developed for graphical presentations including a lesser amount regarding the proper use of chartjunk. As a result of the concern over misleading graphs, several researchers suggested specific criteria to ensure the integrity of the underlying data within the graph. Tufte developed an equation which accurately measures the degree of distortion in a graph (Tufte, 1983:56-57). Additionally, Tufte, Cleveland, Christensen and Larkin, Taylor and Anderson, plus several other authors, propose specific criteria for the production of high integrity graphs (Christensen and Larkin, 1992; Cleveland, 1985; Taylor and Anderson, 1986; Tufte, 1983).

Several graphical experiments were investigated to see if there was any empirical evidence that violating specific criteria may cause the readers of graphics to be misled because of distortions of data contained in the graph (Carvalho and McMillan, 1992; Johnson and Rice,

1990; Kern, 1991; Larkin, 1990; Steinbart, 1989; Taylor, 1983). Despite a substantial number of experiments concerning graphical presentations, no experiments could be found which empirically verified the effects on perceptions or decision making when graphs included forms of chartjunk. Barber and Dunn's experiment measuring the effects of iconic graphs represents the closest efforts at measuring chartjunk issues to date. As a result of the lack of guidelines and empirical evidence on the effects of chartjunk, an experiment was conducted in which specific forms of chartjunk were manipulated. The results of that experiment were reported in Chapter IV of this thesis.

Additionally, research was conducted to determine what preferences, if any, exist concerning various forms of chartjunk versus graphical presentations which do not contain chartjunk. It was determined that many authors do not believe chartjunk or fill patterns are appropriate and some even feel that they may distort the viewer's perception of the graph (Cleveland, 1985:24, 36; Tufte, 1983:107-108, 111). Additionally, some studies have shown that the graphical format may be capable of manipulating the decision made by the viewer of the graphical display (Jarvenpaa, 1987:298; Vogel, Dickson, and Lehman, 1986:5-20).

The four Modes of Presentation used in the experiment did not have any effect on the experimental subject's decisions for loan amounts to the fictitious companies. Similarly, the Mode of Presentation had no statistically significant effect on any of the subject's perceptions as they related to loan decisions made. On the basis of the statistical evidence presented in this study, the Mode of Presentation of numerical

information, whether the mode be vertical bar graphs with varying degrees of fill patterns or tabular in format, should not affect an individual's perceptions related to decision making or decisions made on that data. However, the trend of numerical information presented over a period of time, whether the Mode of Presentation be vertical bar graphs with varying degrees of fill patterns or tabular, does have an effect on an individual's perceptions and decisions made on that data.

Additionally, it is worth noting that the Mode of Presentation (i.e., graphical versus tabular modes of presentation) resulted in no significant difference with regards to the experimental results. This statement was true for all dependent responses in the experiment regardless of whether the responses were related to the experimental subject's decision making or perceptions. Previous research into the effects of graphical and tabular representations on decision making has been inconsistent (Vessey, 1991:219). Some studies have found that graphs are better than tables while others suggest the opposite is true. The results of this experiment fit in the middle of this argument and seem to support previous research conducted by DeSanctis and Jarvenpaa (DeSanctis, 1984:463-487; Jarvenpaa, 1988:764-774). The most recent thinking on the graphs versus tables controversy suggests that the task required is the cause of the mixed research results (Vessey, 1991:219). Therefore, it may be important to understand that the particular task (i.e., loan determination task) required by the experimental subjects for this particular type of experiment produced no significant differences in the subject's decision making.

It was noted throughout the experiment that the trend of the numerical information presented for each fictitious company had a statistically significant effect on the experimental subject's perceptions related to decision making, as well as the decisions made on the loans. The only exception to this finding was the perception of confidence associated with the application of the loan criteria and decision rule. In this case only, Trend did not provide any statistically significant effect on the subject's perceptions. In every other instance throughout the experiment, the trend of the information presented for the fictitious companies had an effect on their responses.

One explanation offered that attempts to explain why Trend had an effect on the experimental results is the bias caused by the decision rule used in the experiment. This decision rule required the experimental subjects to determine loan amounts for the fictitious companies based on their perception of the trend of each company's net assets over a four year period. Even though the experimental subject's loan decision responses were normalized, the bias caused by the decision rule could not be completely removed from the experimental results. Thus, unique groups of responses were formed due to the bias created from the decision rule employed in regards to Trend. The effects of Trend on decision making was not the primary concern of this experiment. It may provide an avenue for future research though.

Recommendations For Future Research

It has been demonstrated (Kern, 1991 and Larkin, 1990), that a decision-maker can be misled by manipulated graphs. This experiment has attempted to address a very small facet of research recommended in the

area of graphical modes of presentation and their effects. There are many other facets of chartjunk that have yet to be researched. Future research may prove useful in the analysis of the effects of iconic graphs on decision making or color manipulation and its effects on decision making.

As mentioned previously, it may also be useful to address the subject of trend of information in relation to how it is perceived by experimental subjects. As mentioned above, the manipulation of the trend of net assets for the fictitious companies used in this experiment had an effect on the subject's responses to the decision making and perceptual questions asked in this experiment. Additional research might provide more insight on the exact relationship the trend of information has in decision making analysis.

Another area for future research may be to determine in more detail the way decision makers use visual displays such as graphical presentations to decipher various forms of information such as financial reports or other accounting information. Differences found between different types of decision makers or different levels of decision makers might provide insight into the degree to which graphical presentations are, or are not effective as information tools.

Additionally, this research focused on a target population of mid and upper level DoD managers. The research did not attempt to generalize the findings outside of this target group. Future research that investigates similar manipulations and their effects on a larger population may provide more insight.

Managerial Implications of This Study

This research has proven, to some degree, that the manner in which data are presented can have an impact on decision making. Specifically, the trend of numerical information, whether it be increasing, decreasing, or no change, can alter a decision-maker's perceptions and the decisions made. However, as long as no criteria are violated concerning graphical presentation guidelines, the Mode of Presentation should not influence a decision-maker's perception or decisions made on the information presented. When developing presentations that are to be used as a decision aid if the information is presented in a time-series format, consideration must be given to the effects of the trend of numerical information only.

Previous experiments have shown that gender may be an important factor in graphical presentation and interpretation (MacKay and Villarreal, 1987). For the purposes of this study, the effects on decisions made between male and female subjects were inconclusive. Therefore, no argument can be made on the effects of gender on decision making. In this case, managers must assume that gender does not have a statistically significant impact on decision making. Further research into the area of gender would be required before the gender hypothesis could be rejected.

Appendix A. Experimental Package

This appendix contains a copy of all materials used to administer the paper and pen behavioral experiment except for the end-of-exercise questionnaire which can be found in Appendix D. The instructions, graphs, and tables presented here are slightly smaller than those used in the actual test (i.e., 90% of the original size). Pages 121 through 125 contain the instructions used for all graphical displays. These instructions applied to factorial cells one through three, five through seven, and nine through eleven. Pages 126 through 130 contain the instructions for the tabular display which was used for cells four, eight, and twelve. A total of 36 displays were used during the experiment (i.e. three in each of 12 cells). The factorial cell number, graph versus table, Mode of Presentation, Trend, and associated page numbers where the graphs or tables are located is displayed in Table 36.

Table 36. Location of Experimental Graph by Factorial Design Cell.

Cell Number	Graph or Table	Mode of Presentation	Trend	Page Number (inclusive)
1	Graphical	No Fill Pattern	Increasing	131 - 133
2	Graphical	Light Fill Pattern	Increasing	134 - 136
3	Graphical	Heavy Fill Pattern	Increasing	137 - 139
4	Tabular	Table	Increasing	140 - 142
5	Graphical	No Fill Pattern	No Change	143 - 145
6	Graphical	Light Fill Pattern	No Change	146 - 148
7	Graphical	Heavy Fill Pattern	No Change	149 - 151
8	Tabular	Table	No Change	152 - 154
9	Graphical	No Fill Pattern	Decreasing	155 - 157
10	Graphical	Light Fill Pattern	Decreasing	158 - 160
11	Graphical	Heavy Fill Pattern	Decreasing	161 - 163
12	Tabular	Table	Decreasing	164 - 166

INSTRUCTIONS

INTRODUCTION

Financial statement infromation for three companies is presented on the following pages. You are asked to act as a loan officer in determing whether the companies are eligible for a loan, and if qualified, what amount to loan each company.

The financial data presented are based on fictional information from annual reports. Your evaluation should be based on the financial information presented

Your first evaluation is desired. Please do not change your answers.

Financial information for each company is presented in time-series charts that represent net asset values for each company from 1990 - 1993. The format used for financial information is illustrated at the end of the instructions.

PROCEDURES FOR FILLING OUT THE LOAN INFORMATION SHEET:

The charts shown following the instructions represent financial statement information for a company seeking a loan from your bank. The criteria your bank uses to determine whether a company is eligible for a loan are listed in the steps below:

STEP 1. HOW TO DETERMINE IF AN APPLICANT IS QUALIFIED FOR A LOAN: Determine if the company is running a positive net asset balance. If a company's current year (1993) net assets are positive you must approve the loan application and mark the approve box on the loan information sheet. If a company's 1993 net assets are negative, you must disapprove the loan application and mark the disapprove box on the loan information sheet.

STEP 2. DETERMINING THE AMOUNT OF THE LOAN: If a company's 1993 net asset value is positive, the bank will approve a specified loan amount to be determined by you. The basic decision rule is as follows: If the company's net asset trend is decreasing, the loan amount will be between $10,000 and $30,000; if the company's net asset trend shows no significant change, the amount of the loan will be between $30,001 and $50,000; and if the company's net assets are increasing, the amount of the loan will be between $50,000 and $70,000.

The exact amount of the loan will be determined by you and should be based on analysis of all years data. Fill in the loan amount on the loan information sheet.

(Please turn to the next page)

A display of the loan decision rule has been provided for your benefit below. You may refer to this display or the written instructions as needed during the administration of the test.

LOAN AMOUNT ($)

DECREASING TREND	10,000	◄────►	30,000
NO SIGNIFICANT CHANGE IN TREND	30,001	◄────►	50,000
INCREASING TREND	50,001	◄────►	70,000

(Please turn to the next page)

ADDITIONAL INSTRUCTIONS AND DEFINITIONS:

1. ASSETS: For the purposes of this experiment assets are defined as the total resources (i.e., cash, land, buildings, equipment, accounts receivable, etc.) a company has ownership of as of the date indicated on the chart.

2. LIABILITIES: For the purposes of this experiment, liabilities are defined as the total debt (i.e., accounts payable, notes payable, salaries payable, etc.) a company has accumulated as of the date indicated on the chart.

3. NET ASSETS: For the purposes of this experiment net assets are defined as assets minus liabilities.

4. Length of Test: This exercise will be timed. You will be given 2 minutes per company to view the financial information and mark your responses. The total time for the exercise should not exceed 15 minutes.

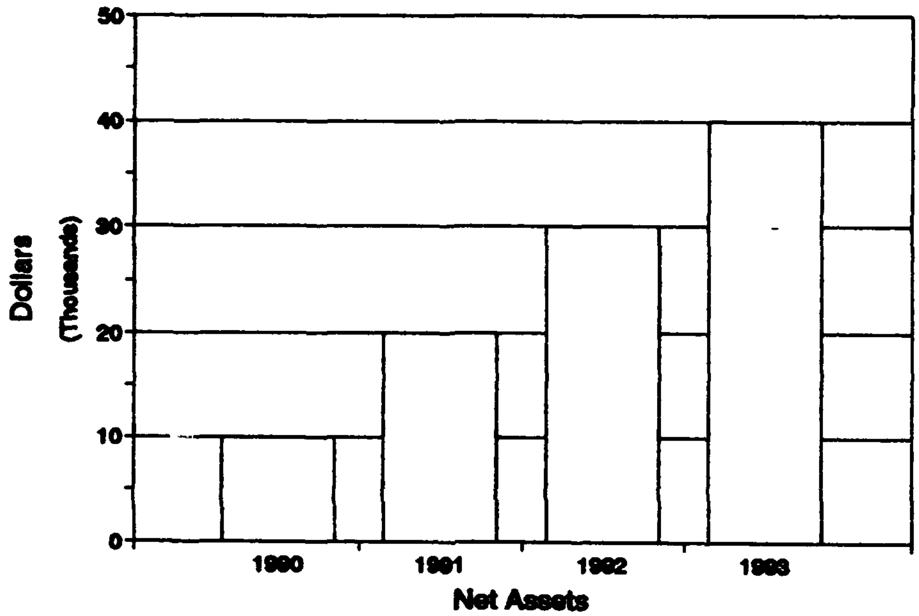
5. You may go back to any part of the test or instructions to ensure that you answer all the questions appropriately. However, DO NOT CHANGE THE ANSWERS to questions already completed.

6. An example of the financial presentation mode and loan information sheet are contained on the following page.

(Please turn to the next page)

EXAMPLE

Company D
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________ (Fill In Amount)

(Please turn to next page)

If you have any questions, please ask them now. No questions will be answered during the administration of the exercise.

(Do not turn the page until told to do so by the Monitor)

INSTRUCTIONS

INTRODUCTION

Financial statement information for three companies is presented on the following pages. You are asked to act as a loan officer in determing whether the companies are eligible for a loan, and if qualified, what amount to loan each company.

The financial data presented are based on fictional information from annual reports. Your evaluation should be based on the financial information presented.

Your first evaluation is desired. Please do not change your answers.

Financial information for each company is presented in time-series tables that represent net asset values for each company from 1990 - 1993. The format used for financial information is illustrated at the end of the instructions.

PROCEDURES FOR FILLING OUT THE LOAN INFORMATION SHEET:

The charts shown following the instructions represent financial statement information for a company seeking a loan from your bank. The criteria your bank uses to determine whether a company is eligible for a loan are listed in the steps below:

STEP 1. HOW TO DETERMINE IF AN APPLICANT IS QUALIFIED FOR A LOAN: Determine if the company is running a positive net asset balance. If a company's current year (1993) net assets are positive you must approve the loan application and mark the approve box on the loan information sheet. If a company's 1993 net assets are negative, you must disapprove the loan application and mark the disapprove box on the loan information sheet.

STEP 2. DETERMINING THE AMOUNT OF THE LOAN: If a company's 1993 net asset value is positive, the bank will approve a specified loan amount to be determined by you. The basic decision rule is as follows: If the company's net asset trend is decreasing, the loan amount will be between $10,000 and $30,000; if the company's net asset trend shows no significant change, the amount of the loan will be between $30,001 and $50,000; and if the company's net assets are increasing, the amount of the loan will be between $50,000 and $70,000.

The exact amount of the loan will be determined by you and should be based on analysis of all years data. Fill in the loan amount on the loan information sheet.

(Please turn to the next page)

A display of the loan decision rule has been provided for your benefit below. You may refer to this display or the written instructions as needed during the administration of the test.

	LOAN AMOUNT ($)		
DECREASING TREND	10,000	⟷	30,000
NO SIGNIFICANT CHANGE IN TREND	30,001	⟷	50,000
INCREASING TREND	50,001	⟷	70,000

(Please turn to the next page)

ADDITIONAL INSTRUCTIONS AND DEFINITIONS:

1. ASSETS: For the purposes of this experiment assets are defined as the total resources (i.e., cash, land, buildings, equipment, accounts receivable, etc.) a company has ownership of as of the date indicated on the chart.

2. LIABILITIES: For the purposes of this experiment, liabilities are defined as the total debt (i.e., accounts payable, notes payable, salaries payable, etc.) a company has accumulated as of the date indicated on the chart.

3. NET ASSETS: For the purposes of this experiment net assets are defined as assets minus liabilities.

4. Length of Test: This exercise will be timed. You will be given 2 minutes per company to view the financial information and mark your responses. The total time for the exercise should not exceed 15 minutes.

5. You may go back to any part of the test or instructions to ensure that you answer all the questions appropriately. However, DO NOT CHANGE THE ANSWERS to questions already completed.

6. An example of the financial presentation mode and loan information sheet are contained on the following page.

(Please turn to the next page)

EXAMPLE

COMPANY D NET ASSETS (1990 - 1993)

YEAR	NET ASSETS
1990	$10,000
1991	$20,000
1992	$30,000
1993	$40,000

Loan Information Sheet (Fill In)

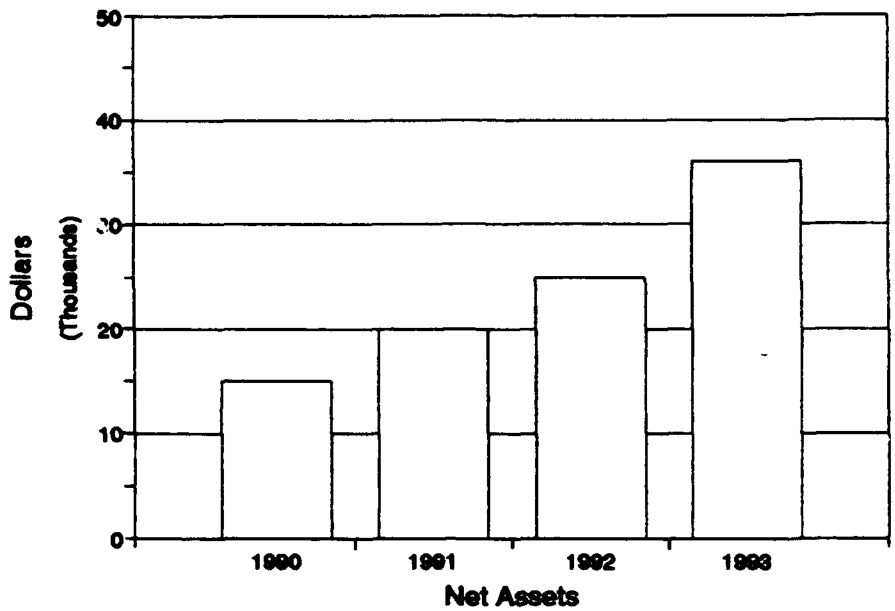
1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________ (Fill In Amount)

(Please turn to next page)

If you have any questions, please ask them now. No questions will be answered during the administration of the exercise.

(Do not turn the page until told to do so by the Monitor)

Company A
Net Assets (1990 - 1993)



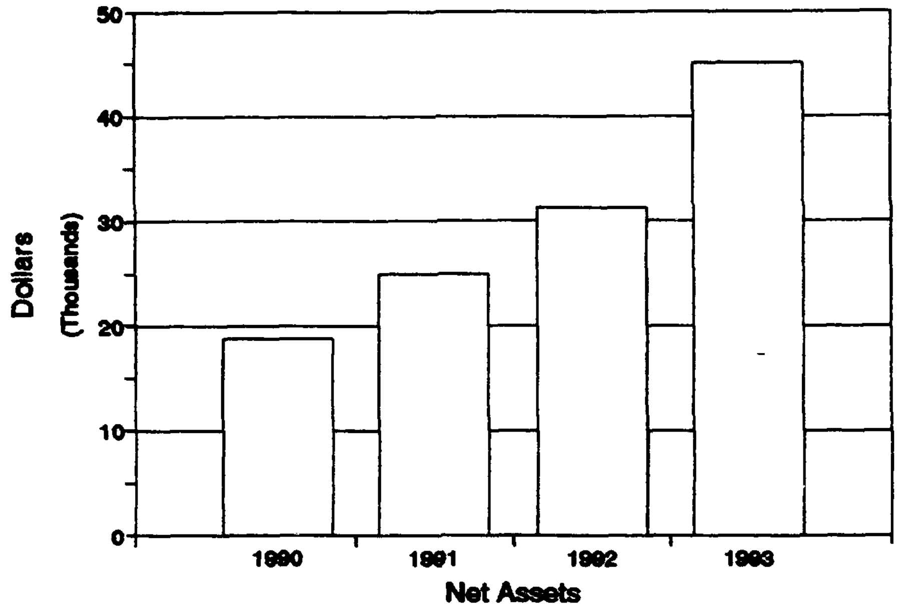
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company B

Net Assets (1990 - 1993)



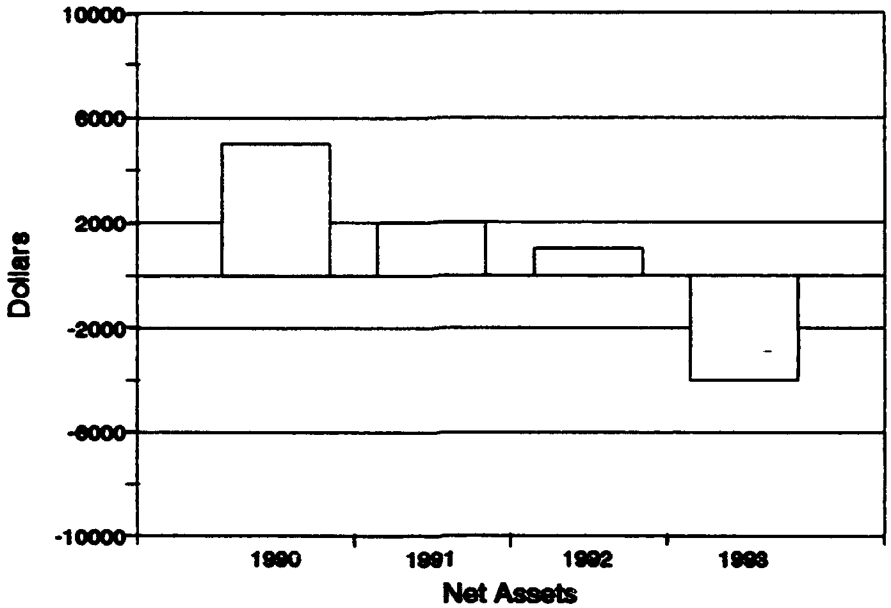
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C

Net Assets (1990 - 1993)



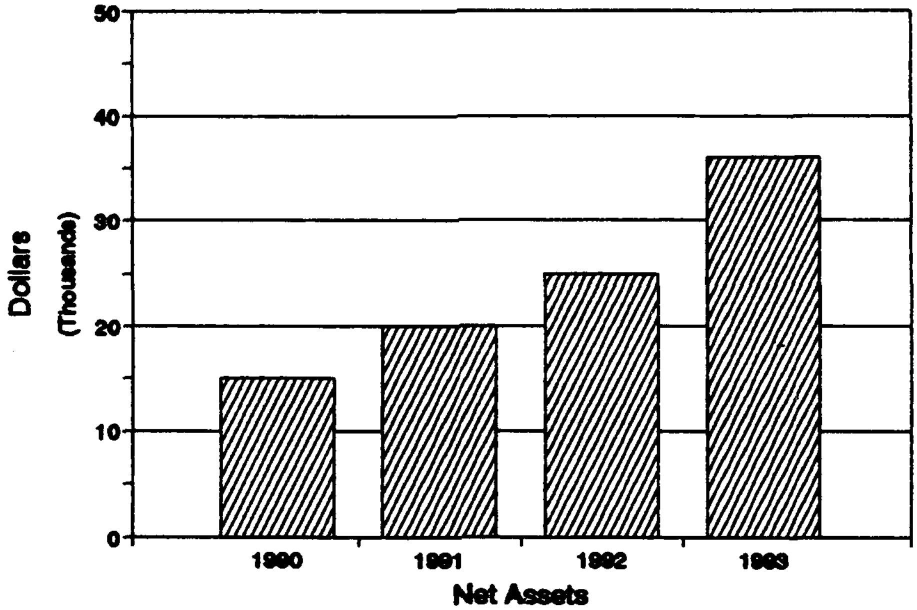
Loan Information Sheet (Fill In)

1. Loan Request: __Approved __ Disapproved
2. Loan Amount Approved: $_________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company A

Net Assets (1990 - 1993)



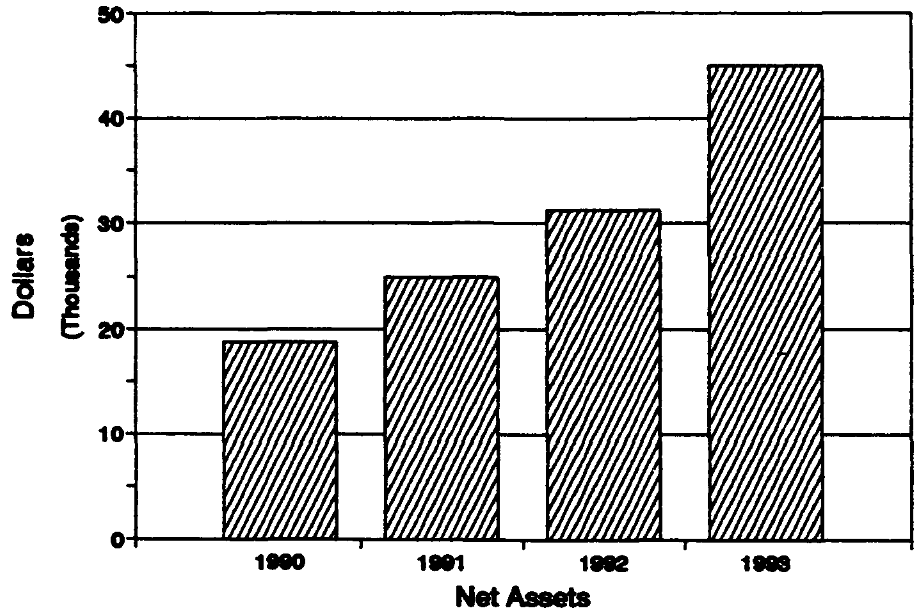
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company B

Net Assets (1990 - 1993)

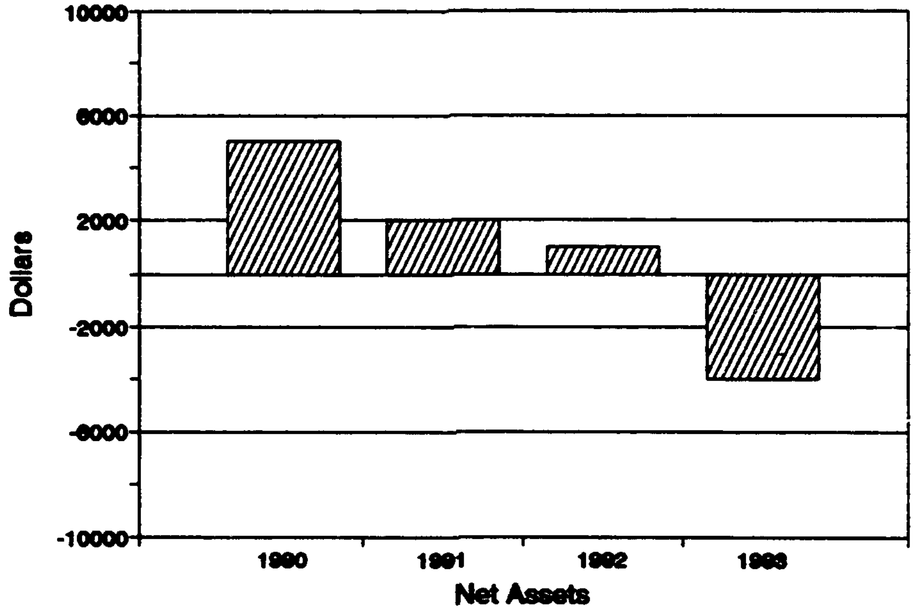


Loan Information Sheet (Fill in)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C
Net Assets (1990 - 1993)

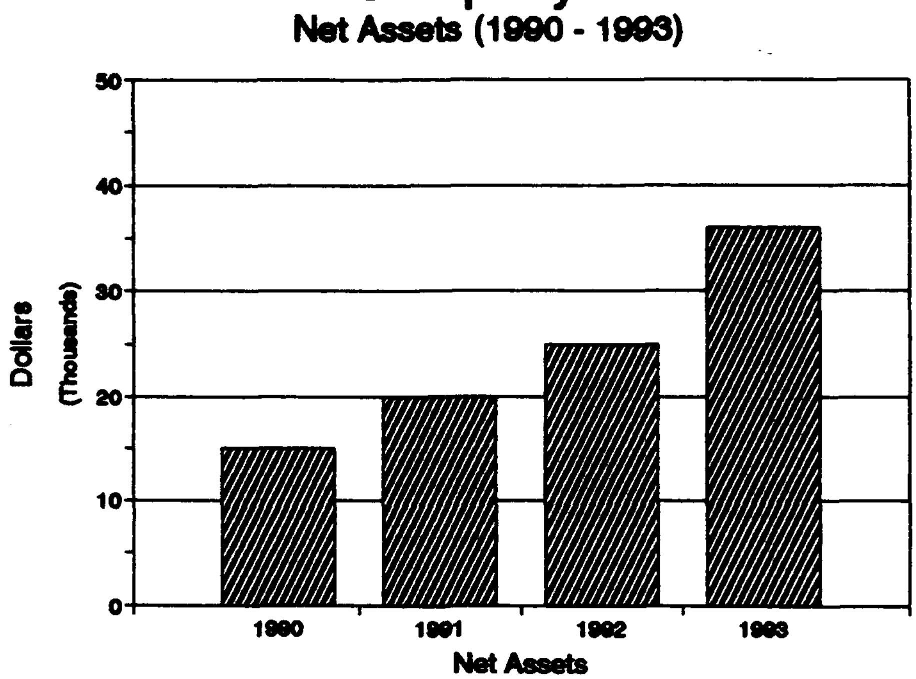


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

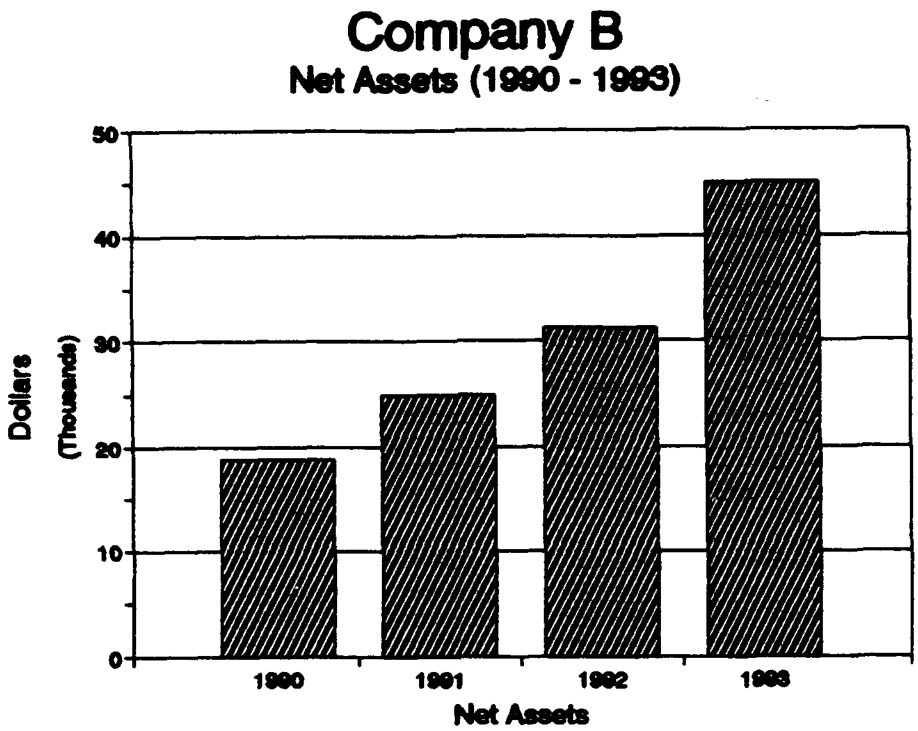
Company A



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

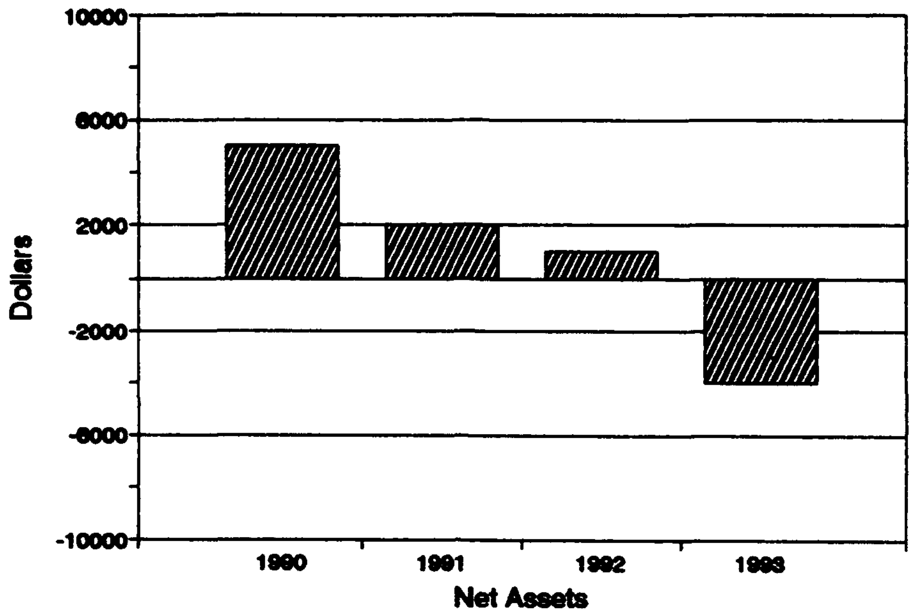


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

COMPANY A ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$15,000
1991	$20,000
1992	$25,000
1993	$36,000

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

COMPANY B ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$18,750
1991	$25,000
1992	$31,250
1993	$45,000

Loan Information Sheet (Fill in)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $___________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

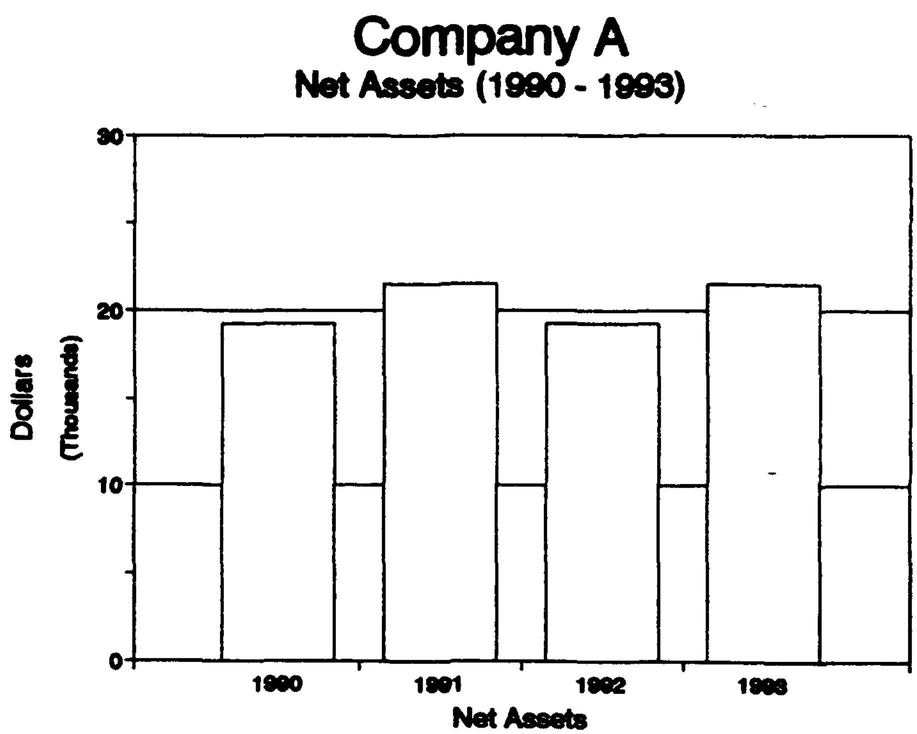
COMPANY C ASSETS AND LIABILITIES (1990 - 1993)

YEAR	**NET ASSETS**
1990	$5,000
1991	$2,000
1992	$1,000
1993	$ -4,000

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_____________(Fill In Amount)

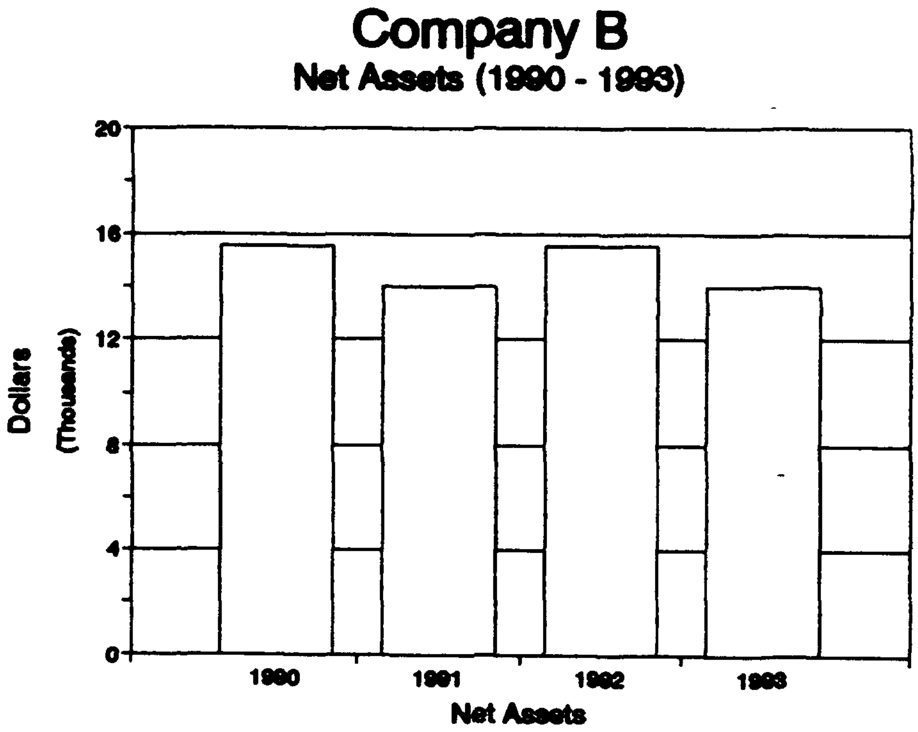
(Do not turn page until told to do so by Monitor)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)



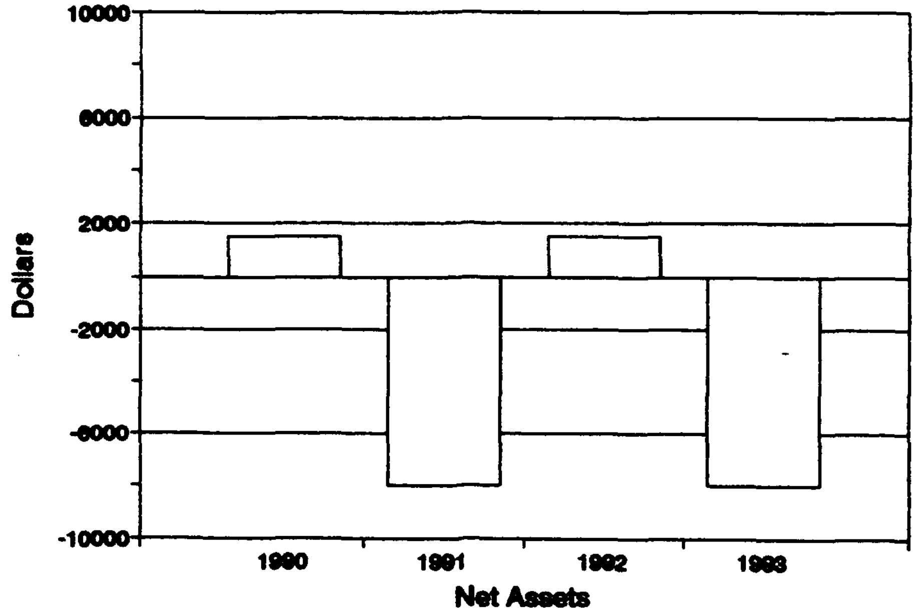
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C

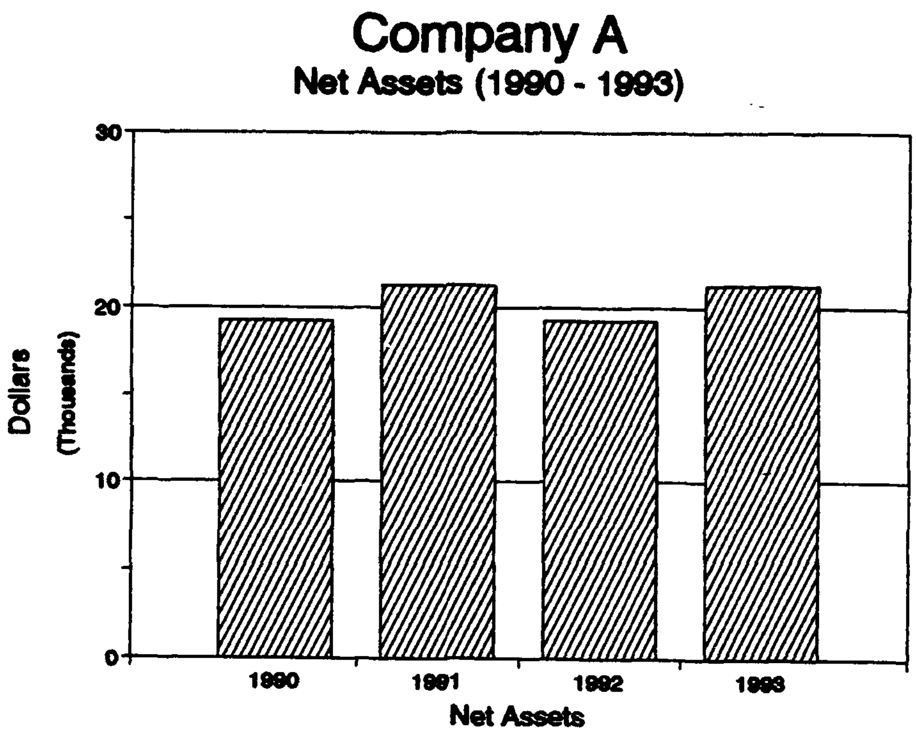
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

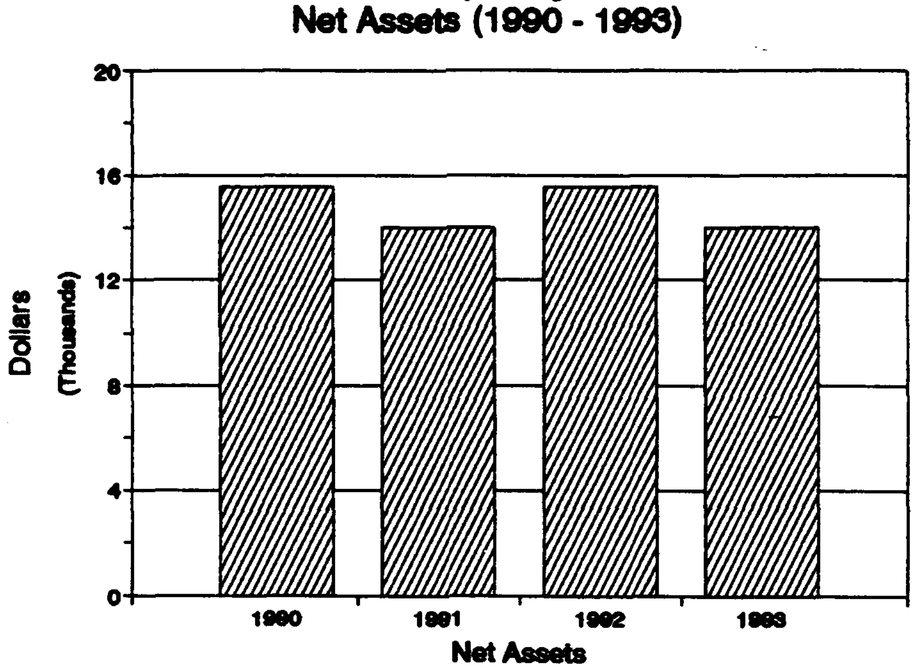


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

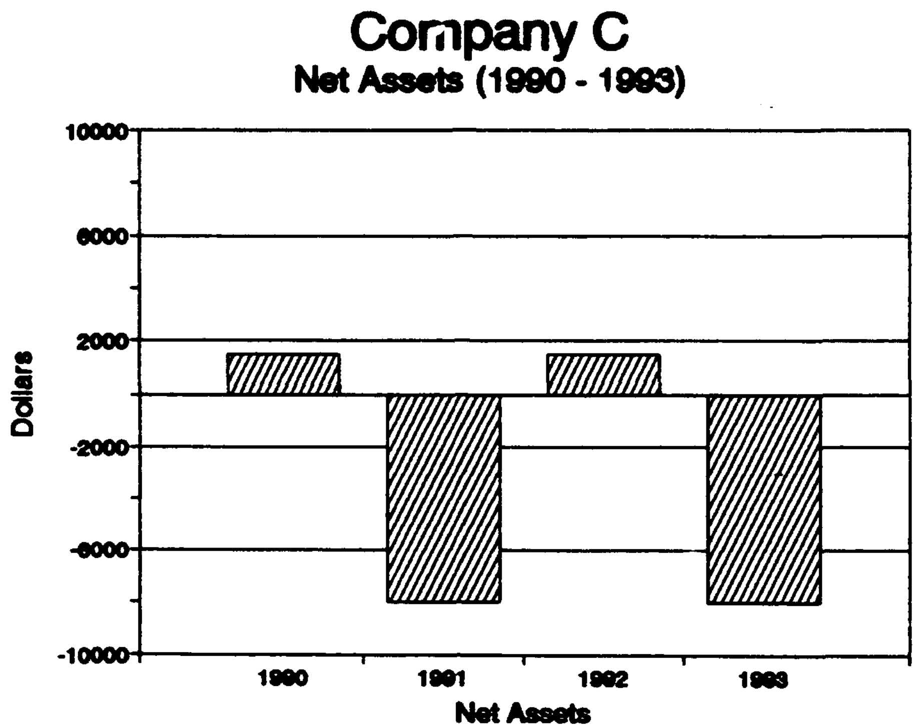
Company B



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)



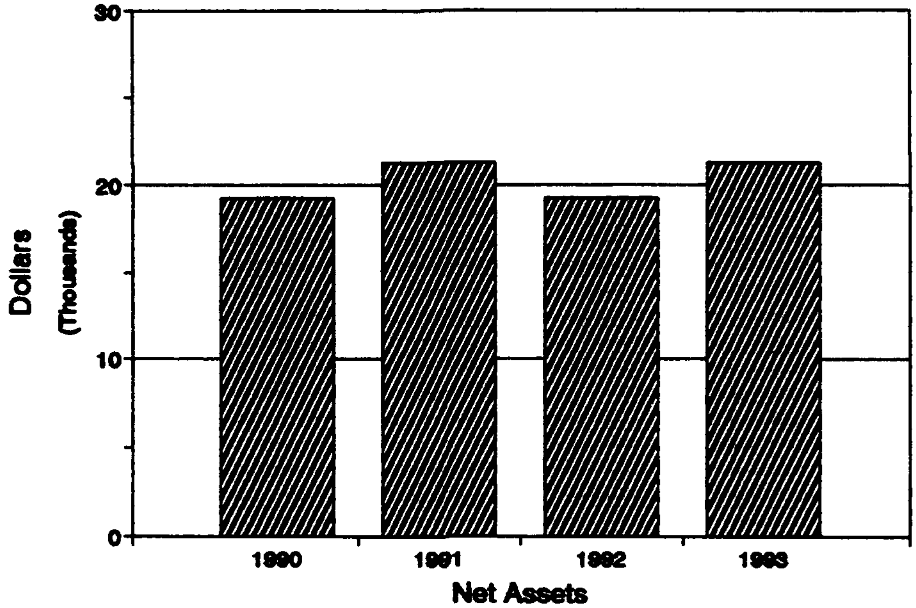
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company A

Net Assets (1990 - 1993)



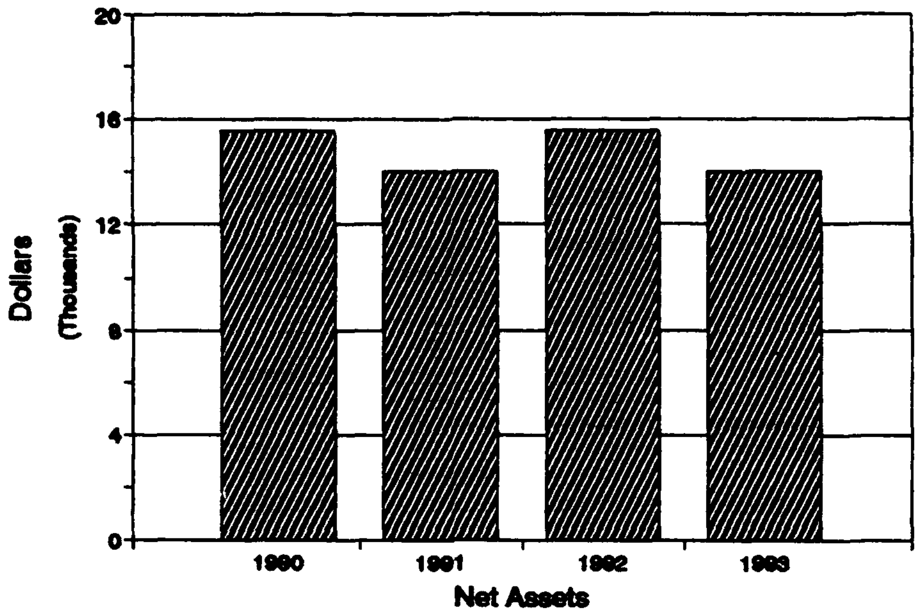
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company B

Net Assets (1990 - 1993)



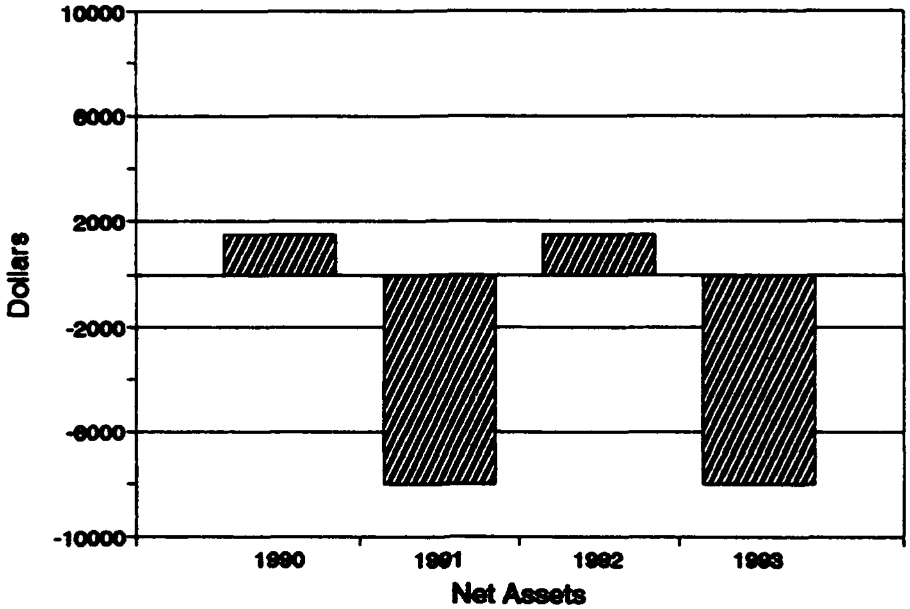
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C

Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

COMPANY A ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$19,250
1991	$21,250
1992	$19,250
1993	$21,250

Loan Information Sheet (Fill in)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

COMPANY B ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$15,500
1991	$14,000
1992	$15,500
1993	$14,000

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $____________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

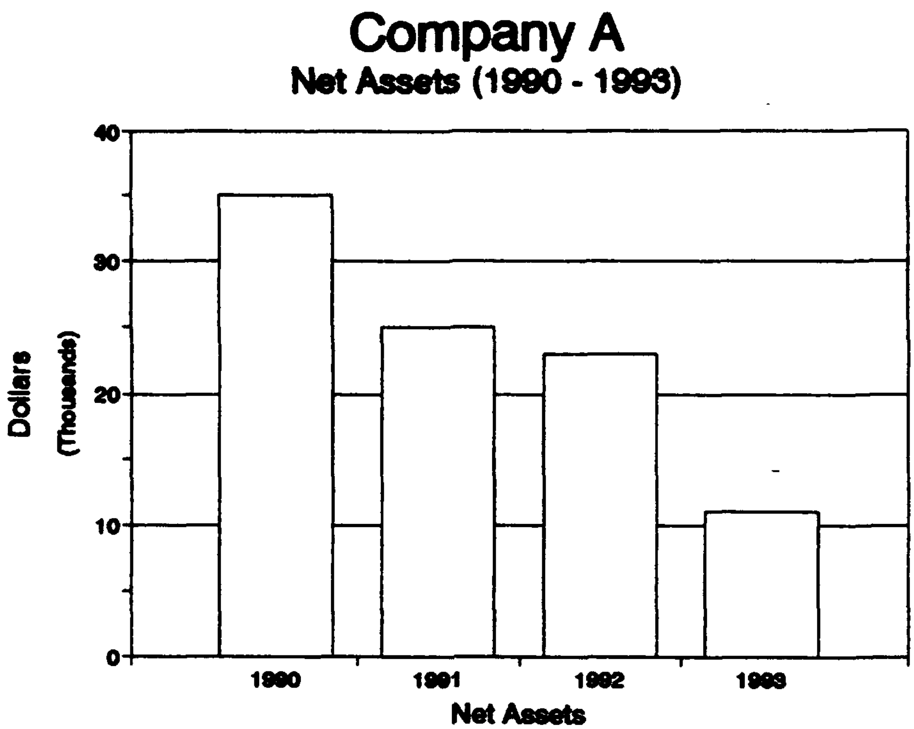
COMPANY C ASSETS AND LIABILITIES (1990 -1993)

YEAR	NET ASSETS
1990	$ 1,500
1991	$-8,000
1992	$ 1,500
1993	$-8,000

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $____________(Fill In Amount)

(Do not turn page until told to do so by Monitor)



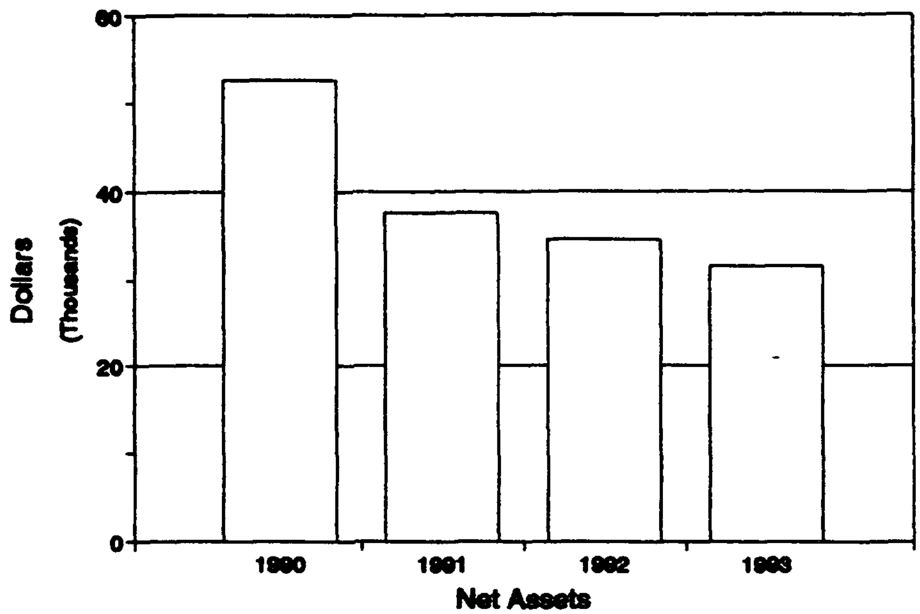
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company B

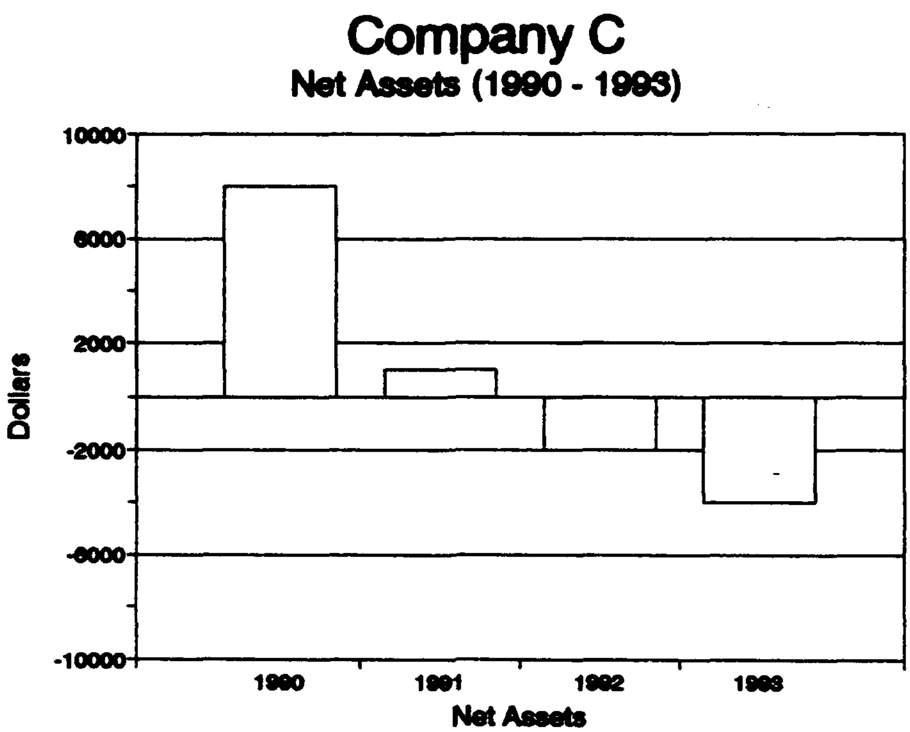
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

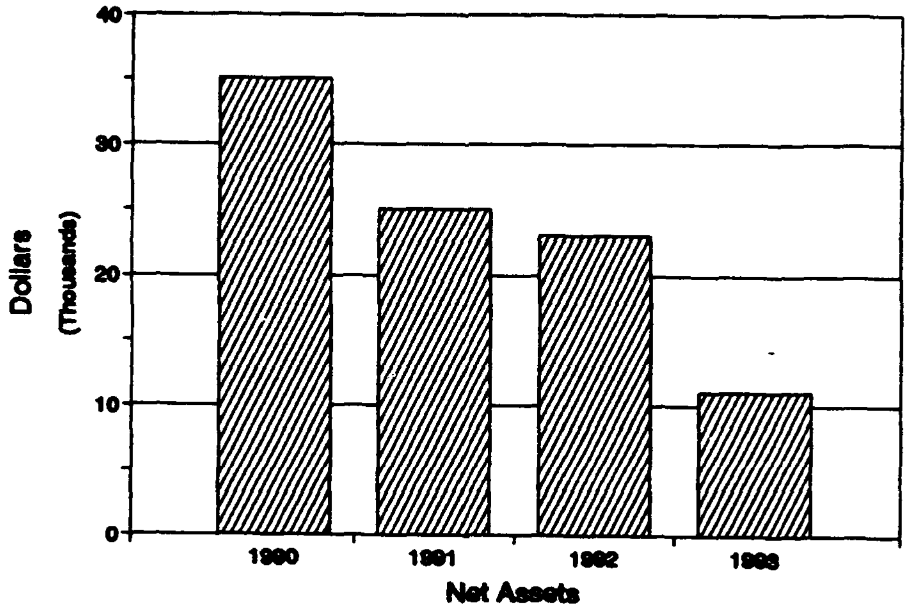


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

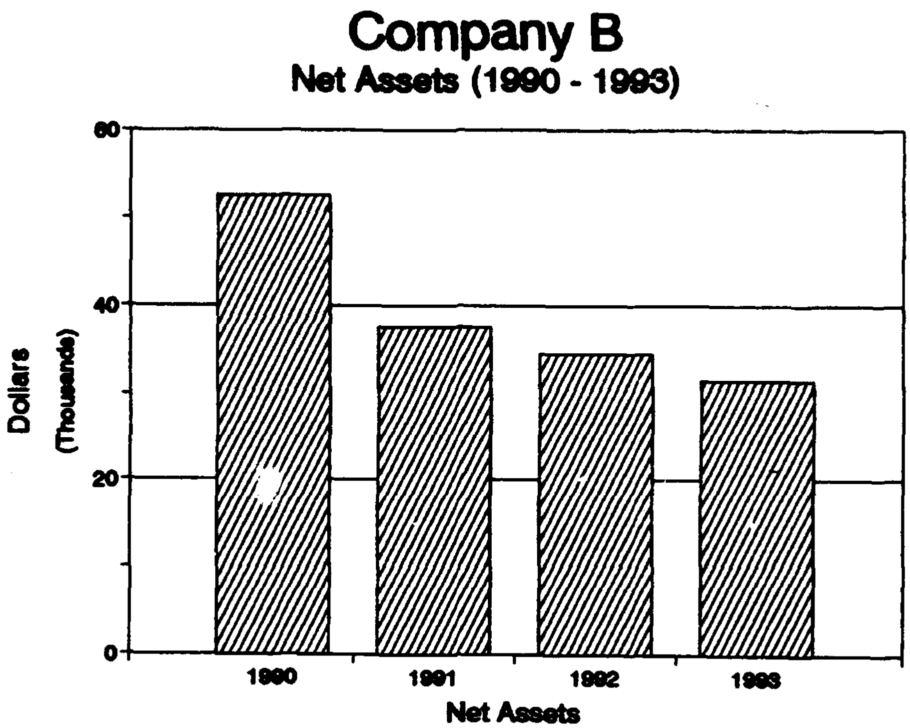
Company A
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)



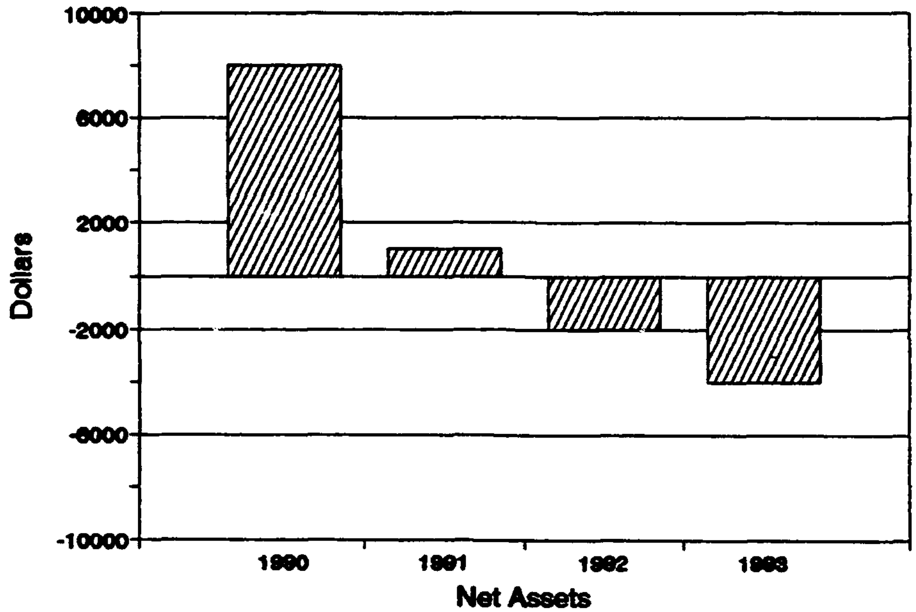
Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C

Net Assets (1990 - 1993)

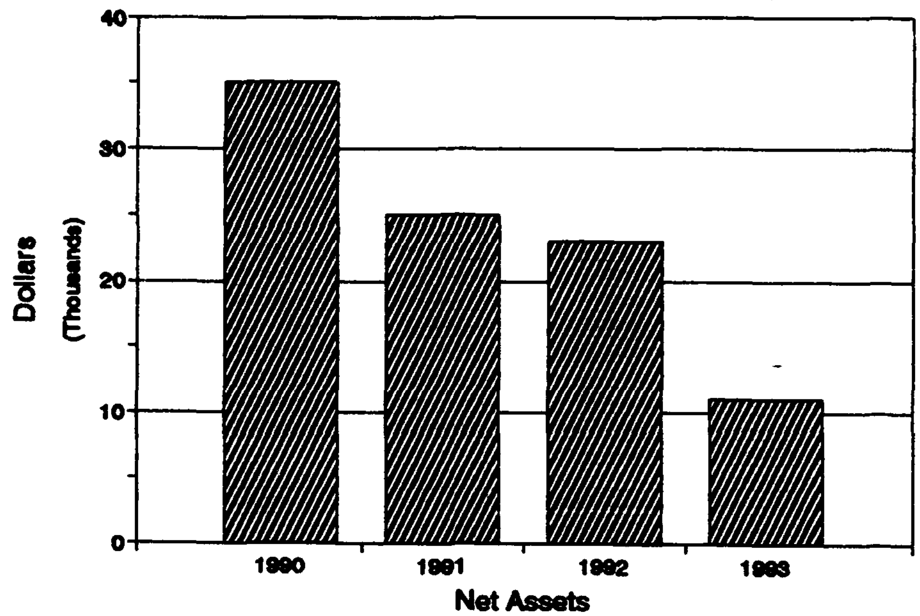


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

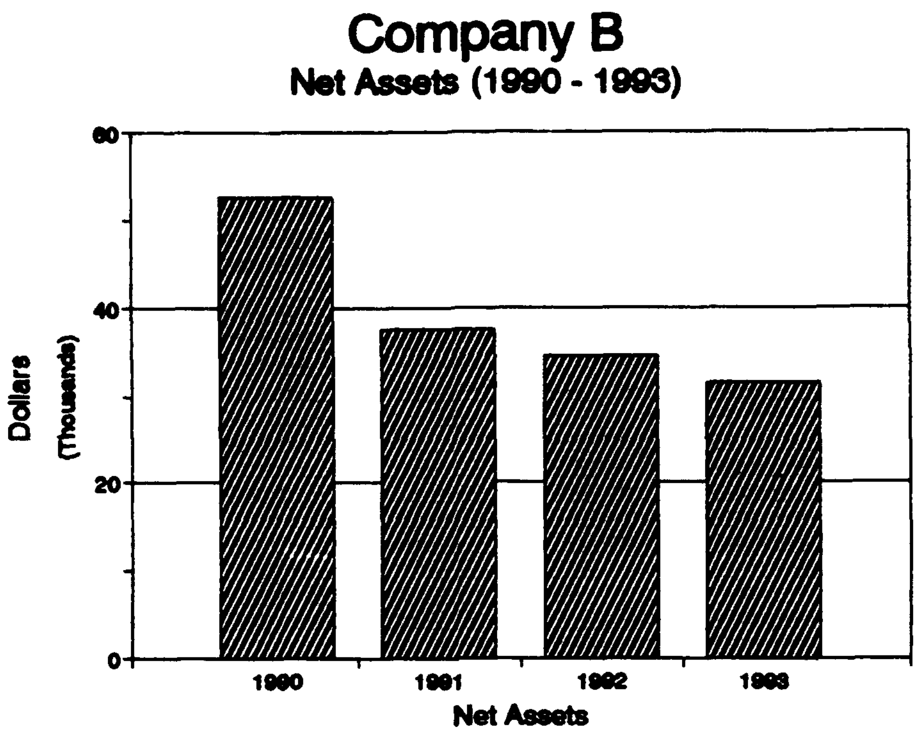
Company A
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_________ (Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

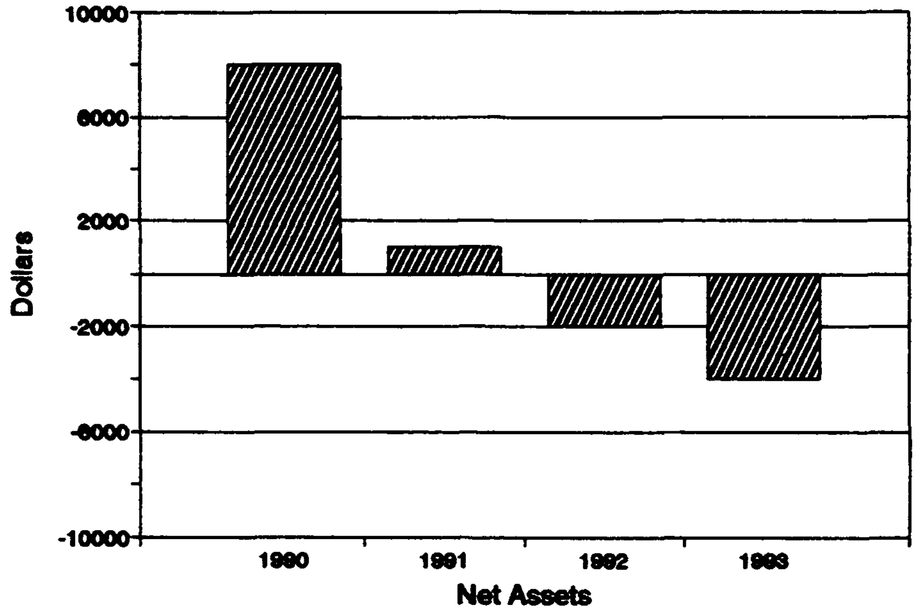


Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $____________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

Company C
Net Assets (1990 - 1993)



Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $________(Fill In Amount)

(Do not turn the page until told to do so by the Monitor)

COMPANY A ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$35,000
1991	$25,000
1992	$23,000
1993	$11,000

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $__________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

COMPANY B ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$52,500
1991	$37,500
1992	$34,000
1993	$31,500

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $____________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

COMPANY C ASSETS AND LIABILITIES (1990 - 1993)

YEAR	NET ASSETS
1990	$ 8,000
1991	$ 1,000
1992	$ -2,000
1993	$ -4,000

Loan Information Sheet (Fill In)

1. Loan Request: __ Approved __ Disapproved
2. Loan Amount Approved: $_____________(Fill In Amount)

(Do not turn page until told to do so by Monitor)

Appendix B. Values Used to Create Experimental Package Graphs

This appendix lists all the values used to create each graph or table used in the experimental package. Table 37 lists the factorial design cell number, company (i.e. Company A, B, or C), years containing the net asset trend data, and the net asset value for each year in the cell display.

Table 37. Values Used to Create Individual Graphs and Tables by Factorial Cell.

Cell Number	Company	Net Asset Value for 1990	Net Asset Value for 1991	Net Asset Value for 1992	Net Asset Value for 1993
1	A	$15,000	$20,000	$25,000	$36,000
	B	$18,750	$25,000	$31,250	$45,000
	C	$ 5,000	$ 2,000	$ 1,000	$-4,000
2	A	$15,000	$20,000	$25,000	$36,000
	B	$18,750	$25,000	$31,250	$45,000
	C	$ 5,000	$ 2,000	$ 1,000	$-4,000
3	A	$15,000	$20,000	$25,000	$36,000
	B	$18,750	$25,000	$31,250	$45,000
	C	$ 5,000	$ 2,000	$ 1,000	$-4,000
4	A	$15,000	$20,000	$25,000	$36,000
	B	$18,750	$25,000	$31,250	$45,000
	C	$ 5,000	$ 2,000	$ 1,000	$-4,000
5	A	$19,250	$21,500	$19,250	$21,500
	B	$15,500	$14,000	$15,500	$14,000
	C	$ 1,500	$-8,000	$ 1,500	$-8,000
6	A	$19,250	$21,500	$19,250	$21,500
	B	$15,500	$14,000	$15,500	$14,000
	C	$ 1,500	$-8,000	$ 1,500	$-8,000

Table 37. Continued.

Cell Number	Company	Net Asset Value for 1989	Net Asset Value for 1990	Net Asset Value for 1991	Net Asset Value for 1992
7	A B C	$19,250 $15,500 $ 1,500	$21,500 $14,000 $-8,000	$19,250 $15,500 $ 1,500	$21,500 $14,000 $-8,000
8	A B C	$19,250 $15,500 $ 1,500	$21,500 $14,000 $-8,000	$19,250 $15,500 $ 1,500	$21,500 $14,000 $-8,000
9	A B C	$35,000 $52,500 $ 8,000	$25,000 $37,500 $ 1,000	$23,000 $34,500 $-2,000	$11,000 $31,500 $-4,000
10	A B C	$35,000 $52,500 $ 8,000	$25,000 $37,500 $ 1,000	$23,000 $34,500 $-2,000	$11,000 $31,500 $-4,000
11	A B C	$35,000 $52,500 $ 8,000	$25,000 $37,500 $ 1,000	$23,000 $34,500 $-2,000	$11,000 $31,500 $-4,000
12	A B C	$35,000 $52,500 $ 8,000	$25,000 $37,500 $ 1,000	$23,000 $34,500 $-2,000	$11,000 $31,500 $-4,000

Appendix C. End-of-Exercise Questionnaire

This appendix contains a copy of the materials used to administer the end-of-exercise questionnaire portion of the behavioral experiment. The instructions and questions presented here are slightly smaller than those used in the actual test (i.e. reproduced at 90% of the original size). ANOVA and frequency tabulation results for the various questions can be found in Appendices E through G.

END-OF-EXERCISE QUESTIONNAIRE

This section of the questionnaire contains a number of statements that relate to the exercise you have just completed. Use the following rating scale to indicate the extent to which you agree or disagree with the statements shown below. Please mark your answer on the scale provided below each statement.

1 = Strongly disagree
2 = Moderately disagree
3 = Slightly disagree
4 = Neither agree nor disagree
5 = Slightly agree
6 = Moderately agree
7 = Strongly agree

1. Given the same information for each company and the same loan criteria again, your decision to approve or disapprove any of the company's loan applications and amounts would be the same.

Strongly Disagree 1----2----3----4----5----6----7 Strongly Agree

2. The loan risk you would associate with Company A was significant.

Strongly Disagree 1----2----3----4----5----6----7 Strongly Agree

3. The loan risk you would associate with Company B was significant.

Strongly Disagree 1----2----3----4----5----6----7 Strongly Agree

4. The loan risk you would associate with Company C was significant.

Strongly Disagree 1----2----3----4----5----6----7 Strongly Agree

5. The trend for net assets for Company A was significant.

Strongly Disagree 1----2----3----4----5----6----7 Strongly Agree

6. The trend for net assets for Company B was significant.

Strongly Disagree 1----2----3----4----5----6----7 Strongly Agree

(Please turn to the next page)

7. The trend for net assets for Company C was significant.

Strongly Disagree 1—2—3—4—5—6—7 Strongly Agree

Use the rating scale below to indicate HOW YOU FEEL about the following three questions.

1 = Very little confidence
2 = Little confidence
3 = A moderate amount of confidence
4 = Great confidence
5 = Very great confidence

8. The confidence you feel about your loan evaluation for Company A is:

Very Little 1—2—3—4—5 Very Great
Confidence Confidence

9. The confidence you feel about your loan evaluation for Company B is:

Very Little 1—2—3—4—5 Very Great
Confidence Confidence

10. The confidence you feel about your loan evaluation for Company C is:

Very Little 1—2—3—4—5 Very Great
Confidence Confidence

11. Were the instructions simple to follow? __ Yes __ No

If no, please indicate weaknesses or suggest means of improvement.

12. Approximately what was the amount of time required to make your loan decisions for all three companies? ___ minutes

13. What was your level of interest in the experimental task?

Very 1—2—3—4—5—6—7 Very
Low Moderate High

(Please turn to the next page)

14. How often do you use graphics in decision making?

__ Never
__ At least once a year
__ At least once a month
__ At least twice a month
__ At least once a week
__ Every other day
__ Daily

15. How often do you construct graphs for presentations?

__ Never
__ At least once a year
__ At least once a month
__ At least twice a month
__ At least once a week
__ Every other day
__ Daily

16. Did you have previous knowledge of this experiment? __ Yes __ No

17. What is your rank or grade? _______

18. How many years of federal employment do you have?

__ 0 to 5
__ 6 to 10
__ 11 to 15
__ 16 to 20
__ 21 to 25
__ 26 to 30
__ over 30
__ None

19. Are you: __ Male __ Female

20. What is your educational background?

__ High School Graduate
__ Some College
__ Associates Degree
__ Baccalaureate Degree
__ Some Graduate Courses
__ Masters Degree
__ Doctoral Degree

21. Which of the following fields do you consider to be the primary basis for your professional experience?

__ Technical
__ Contracts
__ Support
__ Managerial
__ Engineering
__ Other: (Please write in) __________________
__ Scientific
__ Operations

22. If you have any additional comments concerning any part of the experiment or questionnaire, please write them below or on the back of this page.

Thank you for your participation.

Appendix D. Description of Terms and Variables

This appendix contains three tables which describe the terms and variables used throughout this thesis. Table 38a gives a description of some of the general terms that are found in various sections of the thesis and a limited number of tables. Table 38b gives a description of the various terms found within in the statistical outputs and lists what tables or figures they appear in. The description of terms come from the following: (McClave and Benson, 1991: 85, 347, 349, 458, 528, 860-862, 867; Neter, Wasserman, and Kutner, 1990:634; Statgraphics User's Manual, 1992:F21-F27, M9-M25; Statistix User's Manual, 1992:246). Table 38c contains a description of all the variables used within this experiment.

Table 38a. Description of General Terms Used.

TERM	SECTION AFFECTED	DESCRIPTION
α	Chapter III	The probability of making a type I error
β	Chapter III	The probability of making a type II error
Δ or Difference	Chapter III	The difference between the maximum μi and minimum μi
i	Chapter III	Effects of the ith level of the first factor; averaged over the m levels of second factor, the ith level of the of the first adds α; to the overall mean μ.
j	Chapter III	Effect of the jth level of the second factor
ij	Chapter III	Interaction between the ith level of the factor "Trend" and the jth level of the factor "Mode of Presentation."

Table 38a. Continued.

TERM	SECTION AFFECTED	DESCRIPTION
m	Chapter III	Represents factor "Mode of Presentation."
µ/mean	Chapter III	Overall mean response: average of mean responses for the tm populations.
MSE	Chapter III	Refers to the mean square of error of the ANOVA F-statistic. See formula below: $$\frac{\sum_{t=1}^{k}(n_t - 1)s_t^2}{(\sum_{t=1}^{k} n_t) - k}$$ Where: $$s_t^2 = \sum_{i=1}^{n_t}\frac{(x_{it} - \bar{x}_t)^2}{n_t - 1}$$
MST	Chapter III	Refers to the treatment mean of the ANOVA F-statistic. See formula below: $$\bar{x}_t = \frac{\sum_{i=1}^{n_t} X_{it}}{n_t}$$ Where: nt = number of observations for treatment t k = number of treatments n = number of observations d.f. = n - k Xit = ith observation of treatment t
Multi-factor ANOVA	Chapter III	Statistical procedure that analyzes the effects of two or more factors effects on a response variable.
r	Chapter III	The number of factor levels
ϵ or Residual	Chapter III	Deviation of Yijk from the population mean response for the ijth population.

Table 38a. Continued.

TERM	SECTION AFFECTED	DESCRIPTION
Standard Deviation	Chapter III, Descriptive Statistics	A measure of the amount of variability or dispersion about the mean, present in a data set. The square root of the variance.
Standard Error	Chapter III, Descriptive Statistics	Refers to the internal and pooled error of the ANOVA F-statistic. Calculated by the following formula: *Internal*: $\sqrt{\frac{s_t^2}{n_t}}$ *Pooled*: $\sqrt{\frac{MSE}{n_t}}$
t	Chapter III	Represents the factor "Trend."
tm	Chapter III	Represents the "Mode of Presentation" and "Trend" factor combinations.
Variance	Chapter III, Descriptive Statistics	Variation from the mean.
ϕ	Chapter III	The noncentrality parameter used to compute an appropriate sample size for each cell of a fixed effects factorial model.

Table 38b. Description of Terms Used In Statistical Tables.

TERM	TERMINOLOGY	DESCRIPTION	TABLES AFFECTED
Cum Rel Freq	--	Count s frequencies.	Frequency
Cumulative Frequency	--	Cumulative frequencies of a set of data.	Frequency

Table 38b. Continued.

TERM	TERMINOLOGY	DESCRIPTION	TABLES AFFECTED
d.f.	number of degrees of freedom	The number of observations in the data collection that are free to vary after the sample statistics have been calculated. Parameter of the F-statistic.	ANOVA
F	F statistic	The test statistic for ANOVA (see Chapter III).	ANOVA Summary
Frequency	--	Distribution of a set of data.	Frequency
Inter-actions	--	Refers to the combined effect of two factors on the response variable.	ANOVA
Inter-Quartile Range	--	Middle range of data.	Descriptive Statistics
Lower Quartile	--	Lower limit of data classes.	Descriptive Statistics
LS Mean	Least Square Mean	Statgraphic bases all analyses on LS Mean; confidence level for means plot.	ANOVA
LSD	Least Significant Difference	The range test method used to calculate confidence intervals about the treatment means.	ANOVA
MS	Mean Square	The two F-statistic sum of squares divided by their appropriate degrees of freedom.	ANOVA
Median	--	Mid point of a data set.	Descriptive Statistics
Mode	--	The most common number observed.	Descriptive Statistics
One-Way ANOVA	ANOVA	Statistical procedure that analyzes the effect of one qualitative factor on one response variable.	ANOVA

Table 38b. Continued.

TERM	TERMINOLOGY	DESCRIPTION	TABLES AFFECTED
p	p-value	The smallest level of significance at which the null hypothesis would be rejected when a specified test procedure is used on a give set of data.	ANOVA Summary
Relative Frequency	--	Proportion of values versus the number in the total population.	Frequency
Sig Lvl	Significance Level	See p, (p-value) above.	ANOVA
SS	Sum of Squares	There are three sum of squares, SST is the measure of total deviation in the data, SSE is the measure of variation present even if Ho is true, SSTr is the amount of variation due to differences in average values. The sum of squares values are used to calculate the mean square.	ANOVA
Upper Quartile	--	Upper limit of data classes.	Descriptive Statistics
Wilk-Shapiro/ Rankit Plot	--	Procedure which examines whether a variable conforms to a normal distribution	Normality Plots Appendix J

Table 38c. Description of Variables Used in Behavioral Experiment.

VARIABLE	DESCRIPTION
AB	Interaction of "Trend" and "Mode of Presentation."
Mode	Indicates the type of presentation format: 1 = no fill pattern 2 = light fill pattern 3 = heavy fill pattern 4 = tabular

Table 38c. Continued.

VARIABLE	DESCRIPTION
Score A	Response for Company A.
Score B	Response for Company B.
Score C	Response for Company C.
Trend	General direction of net assets: A = increasing B = no change C = decreasing
Q1	End-of-Exercise Questionnaire question 1 responses.
Q2	End-of-Exercise Questionnaire question 2 responses.
Q3	End-of-Exercise Questionnaire question 3 responses.
Q4	End-of-Exercise Questionnaire question 4 responses.
Q5	End-of-Exercise Questionnaire question 5 responses.
Q6	End-of-Exercise Questionnaire question 6 responses.
Q7	End-of-Exercise Questionnaire question 7 responses.
Q8	End-of-Exercise Questionnaire question 8 responses.
Q9	End-of-Exercise Questionnaire question 9 responses.
Q10	End-of-Exercise Questionnaire question 10 responses.
Q11	End-of-Exercise Questionnaire question 11 responses. N = No Y = Yes
Q12	End-of-Exercise Questionnaire question 12 responses.
Q13	End-of-Exercise Questionnaire question 13 responses.
Q14	End-of-Exercise Questionnaire question 14 responses.
Q15	End-of-Exercise Questionnaire question 15 responses.

Table 38c. Continued.

VARIABLE	DESCRIPTION
Q16	End-of-Exercise Questionnaire question 16 responses. N = No Y = Yes
Q17	End-of-Exercise Questionnaire question 17 responses: GG = Government Grade GS = Government Schedule GM = General Manager O = Officer E = Enlisted Contract = Contractor
Q18	End-of-Exercise Questionnaire question 18 responses.
Q19	End-of-Exercise Questionnaire question 19 responses. F = Female M = Male
Q20	End-of-Exercise Questionnaire question 20 responses.
Q21	End-of-Exercise Questionnaire question 21 responses.

Appendix E. Raw Data

This appendix contains all the values for each question as registered by all individual subject who participated in the behavioral experiment. Term and variable definitions are contained in Appendix D.

Table 39. Behavioral Experiment Raw Data.

SUBJECT	SCORE A	SCORE B	SCORE C	TREND	MODE	Q1	Q2
1	50001	70000	0	A	1	7	1
2	50001	60000	0	A	1	5	2
3	50001	60000	0	A	1	7	2
4	60000	60000	0	A	1	5	3
5	50001	65000	0	A	1	1	1
6	55000	60000	0	A	1	6	5
7	50001	50001	0	A	1	7	2
8	60000	60000	0	A	1	7	6
9	70000	70000	0	A	1	6	1
10	50001	50001	0	A	1	4	1
11	70000	70000	0	A	1	7	2
12	50001	60000	0	A	1	6	6
13	50001	70000	0	A	1	7	1
14	50001	50001	0	A	1	4	4
15	60000	65000	0	A	1	6	2
16	30000	30000	0	A	2	3	1
17	50001	50001	0	A	2	6	4
18	65000	65000	0	A	2	5	3
19	50001	50001	0	A	2	6	4
20	70000	70000	0	A	2	7	1
21	60000	70000	0	A	2	7	3
22	50001	60000	0	A	2	7	2
23	50001	55000	0	A	2	7	1
24	70000	70000	0	A	2	4	3
25	50001	50001	0	A	2	7	5
26	60000	65000	0	A	2	7	2
27	70000	70000	0	A	2	7	1
28	50001	50001	0	A	2	4	6
29	50001	60000	0	A	2	5	3
30	60000	65000	0	A	2	6	3
31	50001	50001	0	A	3	7	3
32	70000	70000	0	A	3	7	1
33	65000	70000	0	A	3	5	6
34	65000	65000	0	A	3	7	2
35	55000	60000	0	A	3	1	3
36	55000	60000	0	A	3	6	1

Table 39. Continued.

SUBJECT	SCORE A	SCORE B	SCORE C	TREND	MODE	Q1	Q2
37	70000	70000	0	A	3	7	4
38	60000	65000	0	A	3	3	2
39	50001	70000	0	A	3	5	6
40	70000	70000	0	A	3	7	2
41	60000	65000	0	A	3	6	3
42	55000	55000	0	A	3	6	4
43	60000	60000	0	A	3	7	2
44	50001	70000	0	A	3	6	7
45	70000	70000	0	A	3	7	2
46	50001	55000	0	A	4	7	4
47	70000	70000	0	A	4	1	2
48	55000	60000	0	A	4	7	6
49	60000	65000	0	A	4	7	1
50	60000	70000	0	A	4	6	7
51	50000	70000	0	A	4	7	6
52	50001	60000	0	A	4	7	4
53	60000	61000	0	A	4	7	3
54	60000	50001	0	A	4	7	2
55	60000	65000	0	A	4	5	5
56	65000	67000	0	A	4	7	2
57	50001	55000	0	A	4	6	6
58	65000	70000	0	A	4	7	4
59	50001	65000	0	A	4	5	2
60	70000	70000	0	A	4	7	2
61	50001	50001	0	B	1	5	2
62	55000	50001	0	B	1	1	2
63	50001	50001	0	B	1	4	2
64	50001	50001	0	B	1	6	5
65	55000	50001	0	B	1	7	1
66	60000	50001	0	B	1	7	3
67	60000	50100	0	B	1	6	7
68	50001	50001	0	B	1	7	2
69	60000	60000	0	B	1	7	4
70	65000	65000	0	B	1	7	3
71	50001	50001	0	B	1	2	5
72	70000	60000	0	B	1	7	3
73	60000	50001	0	B	1	7	1
74	60000	60000	0	B	1	6	2
75	60000	60000	0	B	1	7	1
76	50001	60000	0	B	2	7	3
77	50001	50001	0	B	2	1	1
78	60000	60000	0	B	2	6	2
79	70000	65000	0	B	2	7	1
80	60000	64000	0	B	2	1	4
81	51000	50001	0	B	2	7	4
82	70000	60000	0	B	2	5	2
83	60000	55000	0	B	2	6	2
84	60000	50001	0	B	2	6	3

Table 39. Continued.

SUBJECT	SCORE A	SCORE B	SCORE C	TREND	MODE	Q1	Q2
85	51000	51000	0	B	2	7	5
86	55000	50001	0	B	2	7	1
87	50001	50001	0	B	2	7	2
88	60000	70000	0	B	2	7	1
89	70000	70000	0	B	2	5	2
90	60000	60000	0	B	2	2	1
91	60000	55000	0	B	3	7	3
92	50001	50001	0	B	3	7	5
93	60000	51000	0	B	3	5	2
94	65000	55000	0	B	3	6	1
95	60000	50001	0	B	3	6	5
96	60000	55000	0	B	3	7	1
97	60000	50001	0	B	3	6	2
98	60000	60000	0	B	3	7	1
99	50001	50001	0	B	3	7	4
100	65000	55000	0	B	3	7	6
101	70000	70000	0	B	3	6	3
102	50001	50001	0	B	3	7	3
103	50001	50001	0	B	3	6	3
104	65000	51000	0	B	3	7	3
105	60000	70000	0	B	3	7	2
106	55000	50001	0	B	4	5	2
107	50001	50001	0	B	4	6	2
108	70000	70000	0	B	4	5	3
109	50001	50001	0	B	4	3	3
110	50001	50001	0	B	4	7	6
111	50001	50001	0	B	4	7	2
112	50001	50001	0	B	4	7	2
113	50001	50001	0	B	4	1	3
114	50001	50001	0	B	4	5	6
115	50001	50001	0	B	4	7	5
116	60000	50001	0	B	4	7	6
117	70000	70000	0	B	4	1	4
118	55000	51000	0	B	4	7	1
119	50001	50001	0	B	4	7	6
120	70000	70000	0	B	4	7	3
121	55000	51000	0	B	4	6	3
122	65000	57500	0	B	4	5	3
123	50001	70000	0	C	1	6	1
124	50001	50001	0	C	1	6	6
125	50001	60000	0	C	1	7	7
126	50001	70000	0	C	1	7	5
127	50001	65000	0	C	1	6	7
128	50001	70000	0	C	1	4	4
129	52000	68000	0	C	1	7	7
130	50001	50001	0	C	1	7	7
131	50001	65000	0	C	1	7	6
132	60000	65000	0	C	1	5	5

Table 39. Continued.

SUBJECT	SCORE A	SCORE B	SCORE C	TREND	MODE	Q1	Q2
133	51000	55000	0	C	1	7	4
134	50001	50001	0	C	1	4	4
135	50001	50001	0	C	1	6	7
136	50001	55000	0	C	1	1	2
137	52000	70000	0	C	1	5	5
138	55000	65000	0	C	2	7	6
139	50001	60000	0	C	2	7	6
140	50001	65000	0	C	2	7	7
141	50001	50001	0	C	2	4	6
142	50001	60000	0	C	2	1	3
143	50001	65000	0	C	2	6	7
144	50001	70000	0	C	2	5	6
145	70000	70000	0	C	2	5	4
146	50001	50001	0	C	2	7	6
147	50001	70000	0	C	2	6	6
148	50001	50001	0	C	2	7	7
149	70000	70000	0	C	2	6	3
150	50001	60000	0	C	2	5	4
151	55000	51000	0	C	2	7	2
152	50001	50001	0	C	2	7	7
153	50001	70000	0	C	3	6	1
154	70000	70000	0	C	3	4	6
155	50001	65000	0	C	3	7	5
156	50001	50001	0	C	3	7	4
157	50001	60000	0	C	3	6	5
158	50001	55000	0	C	3	4	6
159	50001	50001	0	C	3	5	4
160	50001	55000	0	C	3	7	4
161	55000	65000	0	C	3	4	6
162	50001	70000	0	C	3	6	5
163	50001	60000	0	C	3	7	6
164	50001	65000	0	C	3	7	7
165	65000	60000	0	C	3	6	2
166	50001	70000	0	C	3	7	6
167	50001	60000	0	C	3	7	5
168	50001	60000	0	C	4	7	5
169	50001	50001	0	C	4	6	6
170	50001	50001	0	C	4	5	1
171	50001	55000	0	C	4	7	6
172	70000	60000	0	C	4	7	4
173	55000	70000	0	C	4	7	7
174	50001	55000	0	C	4	7	5
175	51000	70000	0	C	4	6	3
176	50001	50001	0	C	4	5	4
177	50001	70000	0	C	4	7	6
178	50001	70000	0	C	4	7	6
179	60000	60000	0	C	4	6	6
180	50001	60000	0	C	4	6	7

Table 39. Continued.

SUBJECT	SCORE A	SCORE B	SCORE C	TREND	MODE	Q1	Q2
181	50001	60000	0	C	4	6	3
182	51000	51000	0	C	4	7	2

Table 39. Continued.

SUBJECT	Q3	Q4	Q5	Q6	Q7	Q8	Q9
1	3	7	7	7	7	5	5
2	6	7	6	7	7	5	2
3	2	1	7	7	7	4	4
4	3	6	6	6	2	4	4
5	3	7	4	7	3	3	4
6	3	7	5	6	4	3	4
7	1	7	3	2	4	4	4
8	5	1	5	6	7	2	3
9	1	7	6	7	1	3	4
10	1	7	6	7	1	4	4
11	2	7	5	6	6	4	4
12	5	7	5	6	7	3	4
13	1	7	7	7	7	5	5
14	4	6	6	6	6	1	1
15	2	6	5	5	5	4	4
16	1	7	5	5	3	4	4
17	4	6	6	6	6	3	3
18	3	7	5	5	5	4	4
19	4	6	5	5	5	3	3
20	1	7	7	7	7	5	5
21	1	7	6	7	7	1	1
22	2	7	7	7	7	4	4
23	1	7	6	5	5	4	4
24	3	1	2	2	2	2	3
25	2	7	5	6	7	3	3
26	2	7	6	6	7	5	5
27	1	7	5	7	7	4	5
28	6	1	4	3	7	5	5
29	2	5	5	5	5	3	4
30	2	7	5	6	1	3	3
31	1	5	5	6	4	4	5
32	1	7	6	6	7	4	4
33	2	1	1	5	6	3	4
34	1	7	6	6	7	4	4
35	3	6	3	3	6	3	3
36	1	7	6	7	1	4	5
37	4	4	4	4	4	5	5
38	3	7	6	6	7	3	3
39	6	4	6	6	7	3	3
40	1	7	7	7	1	3	4
41	2	6	4	5	3	3	4
42	5	6	5	5	4	4	4
43	2	3	6	6	3	3	3
44	5	7	5	6	7	3	4
45	2	7	5	6	1	4	5
46	2	7	2	4	5	3	4
47	2	6	5	6	7	4	4

Table 39. Continued.

SUBJECT	Q3	Q4	Q5	Q6	Q7	Q8	Q9
48	5	7	6	6	7	4	5
49	1	7	5	6	7	3	4
50	7	7	7	7	7	4	4
51	7	7	5	6	7	5	5
52	3	7	5	6	7	3	4
53	3	7	6	6	1	4	4
54	5	7	5	7	6	5	4
55	6	7	4	5	6	3	4
56	2	7	6	6	6	3	3
57	6	6	6	6	6	4	4
58	4	4	6	6	6	1	1
59	2	6	6	6	6	4	4
60	1	7	7	7	7	4	5
61	4	6	5	5	6	3	2
62	3	6	6	6	2	5	4
63	3	7	4	4	1	3	3
64	7	7	4	4	7	5	2
65	3	6	6	5	7	5	4
66	5	6	2	2	7	5	3
67	7	7	4	4	7	4	4
68	5	7	4	4	6	4	4
69	4	7	4	4	7	3	3
70	3	7	5	5	5	4	4
71	5	6	4	4	7	3	3
72	4	5	3	3	6	4	4
73	3	7	2	6	7	5	5
74	2	6	3	3	6	4	4
75	1	7	1	1	7	5	5
76	3	7	2	2	7	3	3
77	3	6	4	4	7	5	4
78	2	5	6	6	7	3	3
79	1	7	6	6	7	5	5
80	4	7	2	2	7	4	4
81	7	7	5	5	6	4	3
82	4	6	6	2	6	4	4
83	4	1	1	1	7	3	4
84	4	6	2	2	6	4	3
85	6	7	2	2	2	4	3
86	5	7	6	6	7	4	4
87	6	6	6	5	7	4	3
88	1	7	7	7	7	3	3
89	4	7	3	5	7	5	4
90	1	7	7	7	1	5	3
91	3	7	7	6	7	5	3
92	6	7	3	3	7	3	2
93	5	7	6	3	6	4	3
94	2	7	7	6	7	4	4

Table 39. Continued.

SUBJECT	Q3	Q4	Q5	Q6	Q7	Q8	Q9
95	5	1	6	6	2	3	3
96	2	7	6	6	2	5	5
97	3	6	2	2	2	4	3
98	1	7	4	4	5	4	4
99	5	7	2	2	6	4	3
100	4	1	5	4	7	4	3
101	3	7	2	3	6	4	3
102	2	7	2	2	7	4	4
103	3	6	2	2	5	4	4
104	4	4	6	5	7	4	3
105	3	7	4	4	7	4	5
106	6	7	1	2	7	4	3
107	3	7	3	3	7	4	3
108	5	6	6	6	6	3	3
109	3	5	4	4	6	4	4
110	7	4	4	4	6	2	1
111	2	6	3	3	6	4	4
112	5	7	7	6	7	5	3
113	3	3	6	6	7	3	3
114	6	1	6	6	1	4	4
115	5	6	3	3	6	4	4
116	3	7	6	6	7	5	4
117	4	7	4	4	4	2	2
118	1	6	2	2	2	3	3
119	7	7	6	6	6	3	3
120	3	6	4	4	6	4	4
121	4	6	4	4	5	4	4
122	3	7	3	3	5	4	4
123	3	7	6	5	1	4	2
124	3	7	6	3	7	3	4
125	6	7	7	6	7	5	5
126	2	6	6	2	6	4	4
127	6	7	7	6	7	2	3
128	4	4	7	7	7	3	3
129	4	7	7	6	2	5	4
130	2	7	6	6	7	4	5
131	2	7	6	2	7	4	5
132	6	7	7	6	6	5	4
133	4	7	4	4	3	5	5
134	4	4	4	4	4	3	3
135	6	7	7	7	7	3	4
136	3	6	2	3	6	3	3
137	7	7	4	6	7	4	4
138	3	7	6	6	6	3	4
139	5	7	6	4	6	3	3
140	2	7	6	6	6	3	5
141	5	7	6	5	7	3	3

Table 39. Continued.

SUBJECT	Q3	Q4	Q5	Q6	Q7	Q8	Q9
142	2	6	6	5	5	3	3
143	2	7	6	5	7	5	4
144	2	7	6	5	7	3	4
145	5	6	5	6	6	2	2
146	6	7	6	6	7	5	5
147	3	7	6	3	6	4	5
148	4	1	7	4	7	3	4
149	2	7	7	5	6	5	4
150	4	7	4	4	7	2	3
151	3	7	6	5	7	4	4
152	5	7	6	6	7	5	5
153	1	4	3	2	5	5	5
154	5	7	6	6	6	3	3
155	5	7	7	7	7	5	5
156	3	6	5	4	6	4	4
157	4	7	7	6	7	4	4
158	5	7	6	5	7	1	2
159	5	6	6	4	7	4	3
160	5	7	7	5	6	5	4
161	6	6	6	6	6	4	4
162	6	5	5	5	5	3	3
163	5		6	5	7	2	3
164	5	7	7	6	7	2	3
165	4	5	6	4	6	2	3
166	2	7	6	2	6	5	5
167	4	7	6	5	7	5	5
168	3	7	5	5	7	3	3
169	6	7	7	7	7	3	3
170	4	4	5	4	4	3	3
171	5	7	5	5	6	5	3
172	6	7	4	4	6	4	3
173	7	7	7	7	7	5	5
174	4	7	4	5	7	4	4
175	5	6	6	4	6	3	4
176	4	7	6	5	7	4	4
177	1	7	7	6	7	5	5
178	6	7	7	7	7	3	3
179	3	6	3	2	5	3	4
180	4	7	7	5	7	4	4
181	2	7	5	3	7	4	5
182	2	7	7	7	7	4	4

Table 39. Continued.

SUBJECT	Q10	Q11	Q12	Q13	Q14	Q15	Q16
1	1	Y	4	5	7	7	N
2	3	Y	1	6	4	3	N
3	4	Y	0.75	4	4	3	N
4	4	Y	2	5	5	5	N
5	3	Y	0.5	4	5	4	N
6	2	Y	2	5	2	2	N
7	1	Y	5	6	4	2	N
8	5	Y	6	5	3	5	N
9	5	Y	3	5	5	3	N
10	4	Y	2	1	6	5	N
11	4	Y	3	4	7	4	N
12	5	Y	1	3	2	2	N
13	5	Y	1.5	6	2	1	N
14	1	Y	0.25	2	1	1	N
15	3	Y	2	4	3	3	N
16	2	Y	1	5	2	2	N
17	1	Y	2	5	3	3	N
18	1	Y	3	4	3	5	N
19	3	Y	1	4	3	3	N
20	5	Y	0.5	4	1	1	N
21	1	Y	1	3	4	4	N
22	4	Y	1	5	6	5	N
23	3	Y	1	3	3	4	N
24	2	Y	2	4	3	3	N
25	4	Y	1	5	3	3	N
26	5	Y	1.5	6	2	1	N
27	5	Y	1	5	3	3	N
28	5	Y	5	4	2	3	N
29	3	Y	1	5	2	3	N
30	3	Y	0.5	4	3	3	N
31	2	Y	1	4	7	2	N
32	1	Y	5	4	4	1	N
33	5	Y	1	4	2	1	N
34	5	Y	1	5	3	3	N
35	5	Y	1	4	2	3	N
36	1	Y	1	4	4	4	N
37	5	Y	1	1	5	3	N
38	4	Y	1.5	5	5	5	N
39	5	Y	2	5	2	3	N
40	5	Y	2	6	4	5	N
41	5	Y	1	4	7	4	N
42	4	Y	2	5	4	3	N
43	3	Y	0.5	4	2	1	N
44	5	Y	3	5	5	5	N
45	1	Y	1	5	2	3	N
46	5	Y	5	1	4	3	N
47	4	Y	0.5	3	2	3	N

Table 39. Continued.

SUBJECT	Q10	Q11	Q12	Q13	Q14	Q15	Q16
48	5	Y	3	6	4	4	N
49	5	Y	0.5	2	7	5	N
50	4	Y	1	5	1	2	N
51	5	Y	2	5	5	2	N
52	5	Y	0.5	5	5	5	N
53	5	Y	3	5	6	5	N
54	5	Y	3	5	3	3	N
55	5	Y	1.5	4	3	3	N
56	4	Y	5	4	3	3	N
57	4	Y	3	4	4	4	N
58	1	Y	0.5	2	3	3	N
59	2	Y	1	4	6	6	N
60	5	Y	5	6	5	3	N
61	4	Y	1	4	6	5	N
62	2	Y	5	6	6	5	N
63	1	Y	0.5	5	3	3	N
64	5	Y	1	4	1	2	N
65	5	Y	1	4	3	2	N
66	1	Y	0.25	6	7	7	N
67	4	Y	1	4	2	4	N
68	4	Y	1	4	5	4	N
69	3	Y	0.5	1	7	7	N
70	4	Y	0.5	4	3	3	N
71	3	Y	0.5	5	3	3	N
72	4	Y	0.1	3	7	7	N
73	5	Y	2	6	3	2	N
74	4	Y	3	3	5	3	N
75	5	Y	3	5	4	3	N
76	5	Y	1	4	7	5	N
77	5	Y	0.5	6	6	6	N
78	2	Y	3	5	6	5	N
79	5	Y	2	7	3	2	N
80	5	Y	1	5	5	3	N
81	3	Y	1	5	3	3	N
82	1	Y	2	4	1	1	N
83	5	Y	1	5	3	2	N
84	2	Y	3	5	2	2	N
85	4	Y	1	5	5	4	N
86	5	Y	3	5	2	3	N
87	5	Y	0.5	6	3	5	N
88	3	Y	1	1	3	6	N
89	5	Y	0.5	4	2	2	N
90	5	Y	1	6	7	6	N
91	4	Y	1	5	4	3	N
92	5	Y	1	5	4	1	N
93	4	Y	1	4	7	3	N
94	4	Y	5	6	3	6	N

Table 39. Continued.

SUBJECT	Q10	Q11	Q12	Q13	Q14	Q15	Q16
95	5	Y	1	6	5	5	N
96	5	Y	3	6	6	5	N
97	3	Y	0.5	2	3	5	N
98	2	Y	0.5	4	6	6	N
99	5	Y	1	7	2	2	N
100	4	Y	3	5	1	5	N
101	5	Y	3	3	2	1	N
102	2	Y	1	4	5	5	N
103	2	Y	2	5	3	3	N
104	5	Y	1	1	3	3	N
105	5	Y	4	6	4	4	N
106	5	Y	5	4	3	3	N
107	5	Y	1	4	1	1	N
108	3	Y	1	1	5	4	N
109	2	Y	0.5	6	7	3	N
110	4	Y	1	2	2	1	N
111	4	Y	2.5	5	5	5	N
112	5	Y	0.5	6	3	3	N
113	4	Y	0.15	5	4	3	N
114	4	Y	5	6	5	5	N
115	5	Y	4	4	7	5	N
116	5	Y	1	5	2	3	N
117	4	Y	0.5	4	3	3	N
118	5	Y	5	3	2	1	N
119	3	Y	1	5	5	3	N
120	4	Y	1	1	5	5	N
121	4	Y	2	5	3	3	N
122	4	Y	2	4	1	1	N
123	4	Y	4	4	4	3	N
124	5	Y	1	4	2	2	N
125	5	Y	1	6	5	3	N
126	4	Y	0.5	4	3	2	N
127	5	Y	1	5	3	2	N
128	3	Y	1	1	5	5	N
129	5	Y	1	2	3	2	N
130	5	Y	1	6	3	3	N
131	5	Y	1	4	4	2	N
132	4	Y	0.1	1	6	5	N
133	5	Y	1	6	2	2	N
134	3	Y	1	3	1	1	N
135	5	N	5	3	4	2	N
136	3	Y	1	1	1	3	N
137	1	Y	1	4	4	3	N
138	4	Y	4	6	2	2	N
139	4	Y	1	6	3	4	N
140	5	Y	2	3	4	5	N
141	3	Y	2	2	1	2	N

Table 39. Continued.

SUBJECT	Q10	Q11	Q12	Q13	Q14	Q15	Q16
142	3	Y	0.5	3	2	2	N
143	5	Y	3	5	3	3	N
144	5	Y	1	4	5	3	N
145	3	Y	6	4	2	2	N
146	5	Y	1	6	3	3	N
147	4	Y	6	5	3	3	N
148	5	Y	0.5	1	3	3	N
149	4	Y	1	6	3	3	N
150	5	Y	2	2	3	2	N
151	4	Y	1	4	7	5	N
152	5	Y	2	1	2	2	N
153	5	Y	2	3	3	2	N
154	5	N	2	1	1	1	N
155	5	Y	0.5	7	5	5	N
156	4	Y	1	3	7	4	N
157	5	Y	7	6	3	2	N
158	5	N	1	5	3	2	N
159	2	Y	1.5	6	6	4	N
160	5	Y	2	3	5	5	N
161	1	Y	0.5	6	4	3	N
162	3	Y	1	6	5	5	N
163	4	Y	0.2	1	5	3	N
164	5	Y	1	7	5	4	N
165	2	Y	3	4	4	3	N
166	5	Y	0.1	1	5	4	N
167	5	Y	5	2	5	6	N
168	4	Y	1	4	3	3	N
169	5	Y	5	2	6	6	N
170	3	Y	2	7	7	7	N
171	5	Y	1	4	4	2	N
172	1	N	2	1	3	3	N
173	5	Y	0.5	2	3	2	N
174	4	Y	2	6	4	4	N
175	2	Y	0.5	4	4	3	N
176	4	Y	1	5	1	1	N
177	5	Y	3	6	7	5	N
178	3	Y	6	4	2	2	N
179	4	Y	1	4	1	1	N
180	5	Y	3	5	2	2	N
181	5	Y	3	3	2	2	N
182	5	Y	0.5	4	3	2	N

Table 39. Continued.

SUBJECT	Q17	Q18	Q19	Q20	Q21
1	E-4	2	M	3	3
2	O-4	4	M	6	4
3	O-1	1	M	4	4
4	O-5	4	M	6	4
5	O-3	2	M	5	5
6	O-4	3	M	6	4
7	CONTRACT	6	M	1	4
8	O-4	3	M	6	1
9	GS-11	3	F	4	4
10	O-4	3	M	5	5
11	GS-14	6	M	6	4
12	O-2	1	M	6	3
13	O-4	4	M	6	4
14	O-4	3	M	6	8
15	GS-12	3	F	2	1
16	GM-13	3	F	2	2
17	GS-12	5	M	6	4
18	GS-09	1	F	4	4
19	O-2	2	M	5	3
20	O-4	3	F	6	3
21	GM-13	5	M	4	4
22	GS-12	1	F	4	6
23	O-6	5	M	6	4
24	CONTRACT	5	M	3	6
25	GM-14	4	M	6	4
26	O-3	1	M	5	4
27	GS-12	4	M	3	1
28	GS-12	3	M	2	1
29	O-1	1	M	4	6
30	O-3	2	M	6	5
31	O-5	4	M	6	8
32	E-5	3	M	2	4
33	GS-11	4	M	2	1
34	O-2	1	M	5	3
35	O-3	2	F	6	4
36	GS-12	4	M	6	4
37	GS-12	4	M	6	8
38	GS-12	5	M	4	1
39	GS-11	4	F	2	3
40	GS-12	1	F	6	8
41	O-4	5	M	5	1
42	GS-11	5	M	2	1
43	E-7	3	M	2	1
44	O-1	1	M	5	3
45	GS-12	5	F	5	4
46	GS-12	4	F	2	3
47	O-6	5	M	6	3

Table 39. Continued.

SUBJECT	Q17	Q18	Q19	Q20	Q21
48	GS-12	7	M	4	3
49	GS-12	6	M	4	1
50	GS-11	5	F	2	8
51	E-7	4	M	2	3
52	GS-11	2	M	4	6
53	GM-14	7	M	6	4
54	GS-12	4	M	1	1
55	GS-13	7	M	6	3
56	GM-13	1	F	4	8
57	O-4	3	F	4	8
58	O-3	2	M	6	6
59	O-4	3	M	6	4
60	GS-12	5	M	3	4
61	O-3	1	M	4	4
62	O-3	1	M	5	4
63	O-3	3	M	5	4
64	O-3	1	M	4	6
65	O-2	3	M	5	1
66	GS-13	2	M	5	4
67	O-3	2	M	4	3
68	O-3	4	M	4	4
69	GS-12	2	M	5	1
70	O-3	2	M	4	3
71	O-2	1	M	6	3
72	O-4	2	M	6	4
73	O-3	2	M	4	4
74	O-3	3	M	6	8
75	O-4	4	M	6	5
76	O-4	4	M	6	4
77	O-2	1	M	5	3
78	O-3	2	M	4	4
79	O-3	1	F	5	3
80	O-3	3	M	4	4
81	O-3	2	M	4	4
82	GS-11	3	F	2	2
83	O-3	2	F	4	5
84	GS-12	4	F	4	4
85	O-3	2	M	5	5
86	O-3	1	M	4	4
87	O-3	1	M	5	3
88	O-3	2	M	5	4
89	O-3	1	M	4	4
90	O-2	1	M	4	4
91	GS-12	2	M	4	2
92	O-3	2	M	4	3
93	O-3	2	M	5	4
94	GS-12	2	F	4	4

Table 39. Continued.

SUBJECT	Q17	Q18	Q19	Q20	Q21
95	GS-12	2	F	5	4
96	O-3	2	M	4	8
97	O-3	1	M	4	4
98	O-3	3	M	6	4
99	GS-12	7	M	5	1
100	O-3	3	M	4	3
101	GS-12	2	M	5	2
102	GS-12	2	F	6	2
103	GS-12	4	F	6	2
104	GS-12	4	F	3	2
105	GS-12	2	F	5	2
106	O-3	3	M	6	8
107	O-3	2	M	5	4
108	GM-15	6	M	6	4
109	GM-13	6	M	3	4
110	O-2	1	M	4	5
111	O-2	1	M	4	3
112	O-6	6	F	4	4
113	O-4	4	M	7	2
114	O-5	2	M	5	4
115	O-4	4	M	5	3
116	GM-13	3	F	6	7
117	GM-13	6	M	4	1
118	GS-12	4	M	5	2
119	O-3	1	M	4	4
120	GM-13	4	F	3	6
121	GS-12	7	M	4	1
122	O-3	2	M	6	2
123	O-4	3	F	6	6
124	GS-12	5	M	2	3
125	GM-14	3	F	6	4
126	GS-14	5	M	6	1
127	O-5	4	M	6	1
128	GS-13	4	M	6	1
129	GM-14	5	M	6	5
130	O-6	5	M	6	1
131	O-3	2	M	5	4
132	O-3	3	M	6	2
133	O-3	2	M	6	4
134	GS-12	5	M	6	2
135	O-4	3	M	6	8
136	GS-13	6	M	6	4
137	GS-12	2	M	4	3
138	GS-12	2	M	4	1
139	O-3	2	M	6	3
140	O-5	5	M	7	2
141	O-3	2	F	6	2

Table 39. Continued.

SUBJECT	Q17	Q18	Q19	Q20	Q21
142	GS-12	2	M	5	2
143	O-3	3	M	6	5
144	GM-13	3	M	4	4
145	O-5	4	M	6	4
146	GM-14	5	M	6	5
147	GS-13	3	M	6	5
148	GS-12	3	M	4	2
149	O-4	6	M	6	2
150	GS-12	7	M	3	4
151	O-3	4	M	6	4
152	GM-13	5	M	4	5
153	O-3	3	M	6	5
154	GS-12	3	F	4	2
155	GM-13	4	M	4	4
156	O-3	2	M	4	5
157	O-4	3	M	6	4
158	O-3	3	F	6	5
159	GS-13	3	M	6	1
160	GM-13	6	M	4	6
161	GS-12	2	F	6	2
162	O-4	4	M	5	7
163	GS-13	5	M	6	6
164	O-3	2	M	6	4
165	GM-13	6	M	5	1
166	O-3	3	M	5	4
167	O-4	3	M	6	4
168	GS-12	2	M	5	5
169	GS-13	4	M	6	4
170	O-4	4	M	6	4
171	GG-13	3	M	4	2
172	GS-12	2	M	5	2
173	O-4	3	M	4	4
174	O-4	4	M	6	4
175	GM-13	6	M	6	7
176	GM-13	3	M	5	4
177	GS-13	5	M	4	4
178	GS-13	1	F	4	2
179	O-4	3	M	6	8
180	O-2	2	M	5	8
181	O-4	4	M	6	4
182	GM-13	4	M	6	3

Appendix F. Loan Decision Factorial Results

This appendix contains the results of the basic loan decision factorial model. Table 40 presents the basic F and p-values for company A and company B while Tables 41 through 43 show the complete Statgraphic output for company A and Tables 44 through 46 show the output for company B. Term and variable descriptions are contained in Appendix D.

Table 40. Summary ANOVA For Loan Amount Decision.

Factor	Company A F Stat	Company A p-value	Company B F Stat	Company B p-value
Trend	10.256	.0001*	14.420	.0000*
Mode	1.364	.2554	.476	.6992
Interaction	.683	.6639	1.200	.3089

* denotes a statistically significant difference
Note: Company C is not included because the loan amount was a constant i.e. $0.00.

Table 41. Analysis of Variance For Loan Amount Decision For Company A - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	1.0340E0009	2	5.1699E0008	10.256	.0001*
MODE	2.0631E0008	3	6.8771E0007	1.364	.2554
INTERACTIONS					
AB	2.0643E0008	6	34405673	.683	.6639
RESIDUAL	8.5691E0009	170	50406428		
TOTAL (CORRECTED)	1.0016E0010	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 42. Multiple Range Analysis For Loan Amount Decision For Company A Versus TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
C	60	52367.400	X
A	60	57333.717	X
B	62	57587.587	X

contrast	difference	+/- limits	
A - B	-253.871	2540.46	
A - C	4966.32	2559.35	*
B - C	5220.19	2540.46	*

* denotes a statistically significant difference.

Table 43. Multiple Range Analysis For Loan Amount Decision For Company A Versus MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
1	45	54333.889	X
4	47	55561.272	XX
2	45	55822.689	XX
3	45	57333.756	X

contrast	difference	+/- limits	
1 - 2	-1488.80	2955.28	
1 - 3	-2999.87	2955.28	*
1 - 4	-1227.38	2926.17	
2 - 3	-1511.07	2955.28	
2 - 4	261.417	2926.17	
3 - 4	1772.48	2926.17	

* denotes a statistically significant difference.

Table 44. Analysis of Variance For Loan Amount Decision For Company B - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	1.6822E0009	2	8.4108E0008	14.420	.0000
MODE	8.3354E0007	3	2.7785E0007	.476	.6992
INTERACTIONS					
AB	4.1979E0008	6	69965156	1.200	.3089
RESIDUAL	9.9157E0009	170	58327665		
TOTAL (CORRECTED)	1.2101E0010	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 45. Multiple Range Analysis For Loan Amount Decision For Company B Versus TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
B	62	55057.554	X
C	60	60583.550	X
A	60	62050.150	X

contrast	difference	+/- limits	
A - B	6992.60	2732.79	*
A - C	1466.60	2753.11	
B - C	-5526.00	2732.79	*

* denotes a statistically significant difference.

Table 46. Multiple Range Analysis For Loan Amount Decision For Company B Versus MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
1	45	58624.800	X
2	45	58911.400	X
4	47	59007.494	X
3	45	60377.978	X

contrast	difference	+/- limits
1 - 2	-286.600	3179.02
1 - 3	-1753.18	3179.02
1 - 4	-382.694	3147.70
2 - 3	-1466.58	3179.02
2 - 4	-96.0941	3147.70
3 - 4	1370.48	3147.70

* denotes a statistically significant difference.

Note: Company C is not included because the loan amount was a constant i.e. $0.00.

Appendix G. Perceptual Questions - ANOVA Results

This appendix contains the results of the perceptual questions concerning risk, significance of trend, and confidence for the loan decision made by the experimental subjects. Table 47 presents the basic F and p-values for company A, B, and C's loan approval response, i.e. question one of the end-of-exercise questionnaire. Tables 48 through 50 show the complete Statgraphics output for question one of the end-of-exercise questionnaire. Table 51 shows the F and p-values for loan risk, questions two through four, of the end-of-exercise questionnaire, while Tables 52 through 54 show the complete Statgraphic output for company A, Tables 55 through 57 show the output for company B, and Tables 58 through 60 show the output for company C. Table 61 shows the F and p-values for trend significance, questions five through seven, of the end-of-exercise questionnaire, while Tables 62 through 64 show the complete Statgraphic output for company A, Tables 65 through 67 show the output for company B, and Tables 68 through 70 show the output for company C. Finally, Table 71 shows the F and p-values for loan confidence, questions eight through ten, of the end-of-exercise questionnaire, while Tables 72 through 74 show the complete Statgraphic output for company A, Tables 75 through 77 show the output for company B, and Tables 78 through 80 show the output for company C. The end-of-exercise questionnaire is located in Appendix C and a description of terms and variables is contained in Appendix D.

Table 47. Summary ANOVA For Loan Approval Decision.

Factor	F Stat	p-value
Trend	.218	.8043
Mode	.819	.4851
Interaction	.820	.5558

* denotes a statistically significant difference

Table 48. Analysis of Variance For Loan Approval Decision - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	1.1380302	2	.5690151	.218	.8043
MODE	6.4122629	3	2.1374210	.819	.4851
INTERACTIONS					
AB	12.841153	6	2.1401921	.820	.5558
RESIDUAL	443.70196	170	2.6100115		
TOTAL (CORRECTED)	464.09341	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 49. Multiple Range Analysis For Loan Approval Versus TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
B	62	5.7843137	X
A	60	5.8833333	X
C	60	5.9666667	X

contrast	difference	+/- limits
A - B	0.09902	0.57808
A - C	-0.08333	0.58238
B - C	-0.18235	0.57808

* denotes a statistically significant difference.

Table 50. Multiple Range Analysis For Loan Approval Versus MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
1	45	5.6888889	X
2	45	5.6888889	X
4	47	6.0235294	X
3	45	6.1111111	X

contrast	difference	+/- limits
1 - 2	0.00000	0.67248
1 - 3	-0.42222	0.67248
1 - 4	-0.33464	0.66585
2 - 3	-0.42222	0.67248
2 - 4	-0.33464	0.66585
3 - 4	0.08758	0.66585

* denotes a statistically significant difference.

Table 51. Summary ANOVA For Questions 2 - 4 Risk Data.

Factor	Company A F Stat	Company A p-value	Company B F Stat	Company B p-value	Company C F Stat	Company C p-value
Trend	27.960	.0000*	8.269	.0004*	1.531	.2192
Mode	.944	.4209	1.943	.1246	.682	.5639
Interaction	1.120	.3529	.644	.6947	.625	.7105

* denotes a statistically significant difference

Table 52. Analysis of Variance For Risk For Company A - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	161.69901	2	80.849507	27.960	.0000*
MODE	8.18561	3	2.728535	.944	.4209
INTERACTIONS					
AB	19.425875	6	3.2376458	1.120	.3529
RESIDUAL	491.56863	170	2.8915802		
TOTAL (CORRECTED)	680.87912	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 53. Multiple Range Analysis For Risk For Company A By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
B	62	2.8990196	X
A	60	3.0833333	X
C	60	5.0000000	X

contrast	difference	+/- limits	
A - B	0.18431	0.60847	
A - C	-1.91667	0.61299	*
B - C	-2.10098	0.60847	*

* denotes a statistically significant difference.

Table 54. Multiple Range Analysis For Risk For Company A By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
2	45	3.4666667	X
1	45	3.5333333	X
3	45	3.6444444	X
4	47	3.9986928	X

contrast	difference	+/- limits
1 - 2	0.06667	0.70782
1 - 3	-0.11111	0.70782
1 - 4	-0.46536	0.70085
2 - 3	-0.17778	0.70782
2 - 4	-0.53203	0.70085
3 - 4	-0.35425	0.70085

* denotes a statistically significant difference.

Table 55. Analysis of Variance For Risk For Company B - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	45.567931	2	22.783965	8.269	.0004
MODE	16.059379	3	5.353126	1.943	.1246
INTERACTIONS					
AB	10.650109	6	1.7750182	.644	.6947
RESIDUAL	468.43137	170	2.7554787		
TOTAL (CORRECTED)	540.70879	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 56. Multiple Range Analysis For Risk For Company B By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
A	60	2.8666667	X
B	62	3.7794118	X
C	60	4.0333333	X

contrast	difference	+/- limits	
A - B	-0.91275	0.59398	*
A - C	-1.16667	0.59839	*
B - C	-0.25392	0.59398	

* denotes a statistically significant difference.

Table 57. Multiple Range Analysis For Risk For Company B By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
2	45	3.1777778	X
3	45	3.4444444	XX
1	45	3.6222222	XX
4	47	3.9947712	X

contrast	difference	+/- limits	
1 - 2	0.44444	0.69096	
1 - 3	0.17778	0.69096	
1 - 4	-0.37255	0.68416	
2 - 3	-0.26667	0.69096	
2 - 4	-0.81699	0.68416	*
3 - 4	-0.55033	0.68416	

* denotes a statistically significant difference.

Table 58. Analysis of Variance For Risk For Company C - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	7.2261264	2	3.6130632	1.531	.2192
MODE	4.8302288	3	1.6100763	.682	.5639
INTERACTIONS					
AB	8.8409381	6	1.4734897	.625	.7105
RESIDUAL	398.71597	169	2.3592661		
TOTAL (CORRECTED)	419.61326	180			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
1 missing values have been excluded.

Table 59. Multiple Range Analysis For Risk For Company C By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
A	60	6.0333333	X
B	62	6.0745098	X
C	59	6.4714286	X

contrast	difference	+/- limits
A - B	-0.04118	0.54964
A - C	-0.43810	0.55619
B - C	-0.39692	0.55212

* denotes a statistically significant difference.

Table 60. Multiple Range Analysis For Risk For Company C By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
3	44	5.9174603	X
2	45	6.2000000	X
1	45	6.3111111	X
4	47	6.3437908	X

Contrast	difference	+/- limits
1 - 2	0.11111	0.63939
1 - 3	0.39365	0.64318
1 - 4	-0.03268	0.63309
2 - 3	0.28254	0.64318
2 - 4	-0.14379	0.63309
3 - 4	-0.42633	0.63692

* denotes a statistically significant difference.

Table 61. Summary ANOVA For Questions 5 - 7 Significance of Trend Data.

Factor	Company A F Stat	Company A p-value	Company B F Stat	Company B p-value	Company C F Stat	Company C p-value
Trend	20.494	.0000*	22.264	.0000*	4.687	.0104*
Mode	.091	.9649	.508	.6776	1.338	.2639
Interaction	.409	.8722	.265	.9526	.976	.4430

* denotes a statistically significant difference

Table 62. Analysis of Variance For Significance of Trend For Company A - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	87.793306	2	43.896653	20.494	.0000*
MODE	.585187	3	.195062	.091	.9649
INTERACTIONS					
AB	5.2597529	6	.8766255	.409	.8722
RESIDUAL	364.12549	170	2.1419146		
TOTAL (CORRECTED)	457.76374	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 63. Multiple Range Analysis For Significance of Trend For Company A By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
B	62	4.1588235	X
A	60	5.3000000	X
C	60	5.8166667	X

contrast	difference	+/- limits
A - B	1.14118	0.52369 *
A - C	-0.51667	0.52758
B - C	-1.65784	0.52369 *

* denotes a statistically significant difference.

Table 64. Multiple Range Analysis For Significance of Trend For Company A By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
1	45	5.0222222	X
3	45	5.0666667	X
4	47	5.1006536	X
2	45	5.1777778	X

contrast	difference	+/- limits
1 - 2	-0.15556	0.60920
1 - 3	-0.04444	0.60920
1 - 4	-0.07843	0.60319
2 - 3	0.11111	0.60920
2 - 4	0.07712	0.60319
3 - 4	-0.03399	0.60319

* denotes a statistically significant difference.

Table 65. Analysis of Variance For Significance of Trend For Company B - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	91.847808	2	45.923904	22.264	.0000*
MODE	3.141010	3	1.047003	.508	.6776
INTERACTIONS					
AB	3.2754357	6	.5459060	.265	.9526
RESIDUAL	350.65882	170	2.0626990		
TOTAL (CORRECTED)	448.92308	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 66. Multiple Range Analysis For Significance of Trend For Company B By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
B	62	4.0588235	X
C	60	4.9333333	X
A	60	5.8000000	X

contrast	difference	+/- limits
A - B	1.74118	0.51391 *
A - C	0.86667	0.51773 *
B - C	-0.87451	0.51391 *

* denotes a statistically significant difference.

Table 67. Multiple Range Analysis For Significance of Trend For Company B By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
3	45	4.7555556	X
2	45	4.8666667	X
1	45	5.0000000	X
4	47	5.1006536	X

Contrast	difference	+/- limits
1 - 2	0.13333	0.59782
1 - 3	0.24444	0.59782
1 - 4	-0.10065	0.59193
2 - 3	0.11111	0.59782
2 - 4	-0.23399	0.59193
3 - 4	-0.34510	0.59193

* denotes a statistically significant difference.

Table 68. Analysis of Variance For Significance of Trend For Company C - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	29.020058	2	14.510029	4.687	.0104*
MODE	12.420910	3	4.140303	1.338	.2639
INTERACTIONS					
AB	18.131430	6	3.0219051	.976	.4430
RESIDUAL	526.23529	170	3.0955017		
TOTAL (CORRECTED)	585.80769	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 69. Multiple Range Analysis For Significance of Trend For Company C By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
A	60	5.2333333	X
B	62	5.7490196	XX
C	60	6.2166667	X

contrast	difference	+/- limits	
A - B	-0.51569	0.62956	
A - C	-0.98333	0.63424	*
B - C	-0.46765	0.62956	

* denotes a statistically significant difference.

Table 70. Multiple Range Analysis For Significance of Trend For Company C By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
1	45	5.4666667	X
3	45	5.4666667	X
2	45	5.9777778	X
4	47	6.0209150	X

contrast	difference	+/- limits
1 - 2	-0.51111	0.73236
1 - 3	0.00000	0.73236
1 - 4	-0.55425	0.72514
2 - 3	0.51111	0.73236
2 - 4	-0.04314	0.72514
3 - 4	-0.55425	0.72514

* denotes a statistically significant difference.

Table 71. Summary ANOVA For Questions 8 - 10 Level of Confidence Data.

Factor	Company A F Stat	Company A p-value	Company B F Stat	Company B p-value	Company C F Stat	Company C p-value
Trend	2.458	.0887	3.431	.0346*	2.287	.1046
Mode	.316	.8137	.052	.9845	.968	.4093
Interaction	.415	.8683	.364	.9010	.924	.4788

* denotes a statistically significant difference

Table 72. Analysis of Variance For The Level of Confidence For Company A - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	4.3490902	2	2.1745451	2.458	.0887
MODE	.8390998	3	.2796999	.316	.8137
INTERACTIONS					
AB	2.2038160	6	.3673027	.415	.8683
RESIDUAL	150.41569	170	.8847982		
TOTAL (CORRECTED)	157.80769	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 73. Multiple Range Analysis For Level of Confidence For Company A By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
A	60	3.5666667	X
C	60	3.6833333	XX
B	62	3.9450980	X

contrast	difference	+/- limits	
A - B	-0.37843	0.33658	*
A - C	-0.11667	0.33909	
B - C	0.26176	0.33658	

* denotes a statistically significant difference.

Table 74. Multiple Range Analysis For Level of Confidence For Company A By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
4	47	3.6823529	X
2	45	3.6888889	X
3	45	3.7111111	X
1	45	3.8444444	X

contrast	difference	+/- limits
1 - 2	0.15556	0.39154
1 - 3	0.13333	0.39154
1 - 4	0.16209	0.38768
2 - 3	-0.02222	0.39154
2 - 4	0.00654	0.38768
3 - 4	0.02876	0.38768

* denotes a statistically significant difference.

Table 75. Analysis of Variance For Level of Confidence For Company B - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	5.4971169	2	2.7485584	3.431	.0346*
MODE	.1241413	3	.0413804	.052	.9845
INTERACTIONS					
AB	1.7485975	6	.2914329	.364	.9010
RESIDUAL	136.19608	170	.8011534		
TOTAL (CORRECTED)	143.56593	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 76. Multiple Range Analysis For Level of Confidence For Company B By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
B	62	3.4735294	X
C	60	3.8166667	X
A	60	3.8500000	X

contrast	difference	+/- limits	
A - B	0.37647	0.32028	*
A - C	0.03333	0.32266	
B - C	-0.34314	0.32028	*

* denotes a statistically significant difference.

Table 77. Multiple Range Analysis For Level of Confidence For Company B By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
4	47	3.6758170	X
2	45	3.7111111	X
1	45	3.7333333	X
3	45	3.7333333	X

contrast	difference	+/- limits
1 - 2	0.02222	0.37258
1 - 3	0.00000	0.37258
1 - 4	0.05752	0.36890
2 - 3	-0.02222	0.37258
2 - 4	0.03529	0.36890
3 - 4	0.05752	0.36890

* denotes a statistically significant difference.

Table 78. Analysis of Variance For Level of Confidence For Company C - Type I Sums of Squares.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
MAIN EFFECTS					
TREND	7.6935957	2	3.8467978	2.287	.1046
MODE	4.8826762	3	1.6275587	.968	.4093
INTERACTIONS					
AB	9.3278867	6	1.5546478	.924	.4788
RESIDUAL	285.89804	170	1.6817532		
TOTAL (CORRECTED)	307.80220	181			

* denotes a statistically significant difference
All F-ratios are based on the residual mean square error.
0 missing values have been excluded.

Table 79. Multiple Range Analysis For Level of Confidence For Company C By TREND.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
A	60	3.6166667	X
B	62	3.9294118	XX
C	60	4.1166667	X

contrast	difference	+/- limits	
A - B	-0.31275	0.46404	
A - C	-0.50000	0.46749	*
B - C	-0.18725	0.46404	

* denotes a statistically significant difference.

Table 80. Multiple Range Analysis For Level of Confidence For Company C By MODE.

Method: 95 Percent LSD

Level	Count	LS Mean	Homogeneous Groups
1	45	3.6888889	X
2	45	3.8000000	X
3	45	3.9333333	X
4	47	4.1281046	X

contrast	difference	+/- limits
1 - 2	-0.11111	0.53981
1 - 3	-0.24444	0.53981
1 - 4	-0.43922	0.53449
2 - 3	-0.13333	0.53981
2 - 4	-0.32810	0.53449
3 - 4	-0.19477	0.53449

* denotes a statistically significant difference.

Appendix H. Demographic Results

This appendix contains the results of the demographic questions for the experimental subjects as measured during the end-of-exercise questionnaire. Table 81 presents a summary of the basic F and p-values for end-of-exercise demographic responses for both company A and B. Tables 82 through 86 show Statgraphic descriptive statistics ANOVA output for question 14, i.e. graph use in decision making. Tables 87 through 91 show Statgraphic descriptive statistics and ANOVA output for how often the experimental subjects constructed graphs as per end-of-exercise question 15. Tables 92 through 96 show the Statgraphic descriptive statistics and ANOVA output with regard to the experimental subject's rank or grade as found in end-of-exercise question 16. Tables 97 through 101 show Statgraphic descriptive statistics and ANOVA output for question 18, the number of years of federal employment. Statgraphic descriptive statistics and ANOVA output for the gender of the experimental subject, end-of-exercise question 20, is contained in Tables 102 through 106. Tables 107 through 111 show Statgraphic descriptive statistics and ANOVA output for the experimental subject's educational background, as found in end-of-exercise question 15. Finally, Statgraphic descriptive statistics and ANOVA output for the professional experience of the experimental subject, end-of-exercise question 22, is contained in Tables 112 through 116. The end-of-exercise questionnaire is located in Appendix C and a description of terms and variables is contained in Appendix D.

Table 81. Summary ANOVA Results For Demographic Data - Questions 14, 15, and 17 - 21.

Factor	Company A F Stat	Company A p-value	Company B F Stat	Company B p-value
Graph Use	.569	.7550	1.371	.2287
Graph Construction	2.021	.0652	.145	.9899
Rank or Grade	1.479	.1036	1.268	.2154
Federal Employment	.534	.7820	.574	.7509
Gender	4.710	.0313*	.522	.4788
Education Level	1.242	.2873	1.138	.3421
Professional Experience	.945	.4733	.558	.7895

* denotes a statistically significant difference

Table 82. Graph Use Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	1	14	.0769	14	.0769
2	2	31	.1703	45	.2473
3	3	51	.2802	96	.5275
4	4	26	.1429	122	.6703
5	5	30	.1648	152	.8352
6	6	13	.0714	165	.9066
7	7	17	.0934	182	1.0000

Table 83. Graph Use One-Way Analysis of Variance For Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	1.9152E0008	6	31919937	.569	.7550
Within groups	9.8243E0009	175	56138895		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 84. Multiple Range Analysis For Graph Use For Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
6	13	54231.308	X
4	26	54538.962	X
5	30	55033.933	X
2	31	55516.548	X
7	17	56176.941	X
3	51	56647.490	X
1	14	57857.643	X

contrast	difference	+/- limits
1 - 2	2341.09	4762.68
1 - 3	1210.15	4462.70
1 - 4	3318.68	4903.09
1 - 5	2823.71	4787.32
1 - 6	3626.34	5696.87
1 - 7	1680.70	5338.05
2 - 3	-1130.94	3368.46
2 - 4	977.587	3933.33
2 - 5	482.615	3788.03
2 - 6	1285.24	4887.25
2 - 7	-660.393	4463.81
3 - 4	2108.53	3564.22
3 - 5	1613.56	3403.20
3 - 6	2416.18	4595.40
3 - 7	470.549	4142.24
4 - 5	-494.972	3963.12
4 - 6	307.654	5024.17
4 - 7	-1637.98	4613.32
5 - 6	802.626	4911.25
5 - 7	-1143.01	4490.08
6 - 7	-1945.63	5449.48

* denotes a statistically significant difference.

Table 85. Graph Use One-Way Analysis of Variance For Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	5.4336E000	6	90559795	1.371	.2287
Within groups	1.1558E0010	175	66043670		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 86. Multiple Range Analysis For Graph Use For Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
6	13	55846.615	X
1	14	56964.714	XX
7	17	57765.059	XX
3	51	58882.686	XX
2	31	58906.710	XX
4	26	60577.077	XX
5	30	62000.200	X

Contrast	difference	+/- limits
1 - 2	-1942.00	5165.77
1 - 3	-1917.97	4840.40
1 - 4	-3612.36	5318.06
1 - 5	-5035.49	5192.49
1 - 6	1118.10	6179.03
1 - 7	-800.345	5789.84
2 - 3	24.0234	3653.55
2 - 4	-1670.37	4266.23
2 - 5	-3093.49	4108.63
2 - 6	3060.09	5300.88
2 - 7	1141.65	4841.60
3 - 4	-1694.39	3865.87
3 - 5	-3117.51	3691.23
3 - 6	3036.07	4984.34
3 - 7	1117.63	4492.82
4 - 5	-1423.12	4298.54
4 - 6	4730.46	5449.39
4 - 7	2812.02	5003.77
5 - 6	6153.58	5326.92 *
5 - 7	4235.14	4870.10
6 - 7	-1918.44	5910.69

* denotes a statistically significant difference.

Table 87. Graph Construction Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
Never		18	.0989	18	.0989
Once a year		37	.2033	55	.3022
At least once a month		62	.3407	117	.6429
At least twice a month		19	.1044	136	.7473
At least once a week		33	.1813	169	.9286
Every other day		8	.0440	177	.9725
Daily		5	.0275	182	1.0000

Table 88. Graph Construction One-Way Analysis of Variance For Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	6.4902E0008	6	1.0817E0008	2.021	.0652
Within groups	9.3668E0009	175	5.3525E0007		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 89. Multiple Range Analysis For Graph Construction For Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
2	37	52811.378	X
4	19	54790.000	XX
5	33	55455.061	XX
6	8	55625.500	XX
3	62	56839.145	X
7	5	58000.400	XX
1	18	59167.056	X

contrast	difference	+/- limits	
1 - 2	6355.68	4150.30	*
1 - 3	2327.91	3866.77	
1 - 4	4377.06	4750.32	
1 - 5	3711.99	4231.82	
1 - 6	3541.56	6136.78	
1 - 7	1166.66	7300.92	
2 - 3	-4027.77	3000.24	*
2 - 4	-1978.62	4076.16	
2 - 5	-2643.68	3458.01	
2 - 6	-2814.12	5631.13	
2 - 7	-5189.02	6881.35	
3 - 4	2049.15	3787.08	
3 - 5	1384.08	3112.03	
3 - 6	1213.65	5425.54	
3 - 7	-1161.25	6714.16	
4 - 5	-665.061	4159.13	
4 - 6	-835.500	6086.89	
4 - 7	-3210.40	7259.04	
5 - 6	-170.439	5691.48	
5 - 7	-2545.34	6930.82	
6 - 7	-2374.90	8233.35	

* denotes a statistically significant difference.

Table 90. Graph Construction One-Way Analysis of Variance For Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	5.9687E0007	6	9947870	.145	.9899
Within groups	1.2041E0010	17	68807508		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 91. Multiple Range Analysis For Graph Construction For Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
7	5	58000.400	X
2	37	58351.649	X
6	8	58750.250	X
5	33	59000.303	X
3	62	59500.306	X
1	18	59639.222	X
4	19	60058.053	X

contrast	difference	+/- limits
1 - 2	1287.57	4705.66
1 - 3	138.916	4384.19
1 - 4	-418.830	5385.97
1 - 5	638.919	4798.09
1 - 6	888.972	6957.96
1 - 7	1638.82	8277.88
2 - 3	-1148.66	3401.71
2 - 4	-1706.40	4621.60
2 - 5	-648.654	3920.74
2 - 6	-398.601	6384.64
2 - 7	351.249	7802.16
3 - 4	-557.746	4293.84
3 - 5	500.003	3528.46
3 - 6	750.056	6151.55
3 - 7	1499.91	7612.60
4 - 5	1057.75	4715.68
4 - 6	1307.80	6901.39
4 - 7	2057.65	8230.38
5 - 6	250.053	6453.07
5 - 7	999.903	7858.26
6 - 7	749.850	9335.08

* denotes a statistically significant difference.

Table 92. Rank or Grade Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	CONTRACT	2	.01099	2	.0110
2	E-4	1	.00549	3	.0165
3	E-5	1	.00549	4	.0220
4	E-7	2	.01099	6	.0330
5	GG-13	1	.00549	7	.0385
6	GM-13	15	.08242	22	.1209
7	GM-14	5	.02747	27	.1484
8	GM-15	1	.00549	28	.1538
9	GS-09	1	.00549	29	.1593
10	GS-11	7	.03846	36	.1978
11	GS-12	39	.21429	75	.4121
12	GS-13	10	.05495	85	.4670
13	GS-14	2	.01099	87	.4780
14	O-1	3	.01648	90	.4945
15	O-2	10	.05495	100	.5495
16	O-3	46	.25275	146	.8022
17	O-4	26	.14286	172	.9451
18	O-5	6	.03297	178	.9780
19	O-6	4	.02198	182	1.0000

Table 93. One-Way Analysis of Variance For Rank Versus Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	1.4059E0009	18	78103320	1.479	.1036
Within groups	8.6100E0009	163	52821881		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 94. Multiple Range Analysis For Rank Versus Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
E-4	1	50001.000	X
O-1	3	50001.000	XX
GG-13	1	50001.000	XXX
GS-13	10	52000.800	XXXX
GM-14	5	52400.600	XXXXX
O-2	10	53000.700	XXXXX
O-4	26	54231.423	XXXXXX
GM-13	15	54800.400	XXXXXXX
E-7	2	55000.000	XXXXXXXX
O-5	6	55000.667	XXXXXXXX
O-6	4	55000.750	XXXXXXXX
O-3	46	55826.478	XXXXXXXX
GS-12	39	58000.333	XXX X XX
GS-11	7	60000.286	X X XXXX
CONTRACT	2	60000.500	XXXXXXXX
GS-14	2	60000.500	XXXXXXXX
GS-09	1	65000.000	XXXXXXXX
E-5	1	70000.000	X X X
GM-15	1	70000.000	X X X

contrast		difference	+/- limits
E-4	- O-4	-4230.42	14627.9
E-4	- O-1	0.00000	16575.1
E-4	- O-5	-4999.67	15504.6
E-4	- O-3	-5825.48	14509.7
E-4	- CONTRACT	-9999.50	17580.6
E-4	- GS-11	-9999.29	15345.6
E-4	- GS-14	-9999.50	17580.6
E-4	- O-2	-2999.70	15055.1
E-4	- GS-12	-7999.33	14537.4
E-4	- GM-13	-4799.40	14825.3
E-4	- GS-09	-14999.0	20300.3
E-4	- O-6	-4999.75	16048.8
E-4	- GM-14	-2399.60	15724.6
E-4	- E-5	-19999.0	20300.3
E-4	- E-7	-4999.00	17580.6
E-4	- GS-13	-1999.80	15055.1
E-4	- GM-15	-19999.0	20300.3
E-4	- GG-13	0.00000	20300.3
O-4	- O-1	4230.42	8752.65
O-4	- O-5	-769.244	6501.31
O-4	- O-3	-1595.06	3522.00
O-4	- CONTRACT	-5769.08	10533.3
O-4	- GS-11	-5768.86	6112.37
O-4	- GS-14	-5769.08	10533.3
O-4	- O-2	1230.72	5341.37

Table 94. Continued.

contrast		difference +/-	limits	
O-4	- GS-12	-3768.91	3634.34	*
O-4	- GM-13	-568.977	4654.23	
O-4	- GS-09	-10768.6	14627.9	
O-4	- O-6	-769.327	7709.60	
O-4	- GM-14	1830.82	7009.66	
O-4	- E-5	-15768.6	14627.9	*
O-4	- E-7	-768.577	10533.3	
O-4	- GS-13	2230.62	5341.37	
O-4	- GM-15	-15768.6	14627.9	*
O-4	- GG-13	4230.42	14627.9	
O-1	- O-5	-4999.67	10150.2	
O-1	- O-3	-5825.48	8553.55	
O-1	- CONTRACT	-9999.50	13103.8	
O-1	- GS-11	-9999.29	9905.55	*
O-1	- GS-14	-9999.50	13103.8	
O-1	- O-2	-2999.70	9449.29	
O-1	- GS-12	-7999.33	8600.42	
O-1	- GM-13	-4799.40	9078.58	
O-1	- GS-09	-14999.0	16575.1	
O-1	- O-6	-4999.75	10963.4	
O-1	- GM-14	-2399.60	10483.0	
O-1	- E-5	-19999.0	16575.1	*
O-1	- E-7	-4999.00	13103.8	
O-1	- GS-13	-1999.80	9449.29	
O-1	- GM-15	-19999.0	16575.1	*
O-1	- GG-13	0.00000	16575.1	
O-5	- O-3	-825.812	6230.68	
O-5	- CONTRACT	-4999.83	11720.4	
O-5	- GS-11	-4999.62	7986.11	
O-5	- GS-14	-4999.83	11720.4	
O-5	- O-2	1999.97	7412.63	
O-5	- GS-12	-2999.67	6294.86	
O-5	- GM-13	200.267	6933.88	
O-5	- GS-09	-9999.33	15504.6	
O-5	- O-6	-0.08333	9265.79	
O-5	- GM-14	2600.07	8692.08	
O-5	- E-5	-14999.3	15504.6	
O-5	- E-7	0.66667	11720.4	
O-5	- GS-13	2999.87	7412.63	
O-5	- GM-15	-14999.3	15504.6	
O-5	- GG-13	4999.67	15504.6	
O-3	- CONTRACT	-4174.02	10368.5	
O-3	- GS-11	-4173.81	5823.69	
O-3	- GS-14	-4174.02	10368.5	
O-3	- O-2	2825.78	5008.45	
O-3	- GS-12	-2173.86	3124.54	
O-3	- GM-13	1026.08	4268.04	
O-3	- GS-09	-9173.52	14509.7	

Table 94. Continued.

contrast		difference	+/-	limits	
O-3	- O-6	825.728		7482.80	
O-3	- GM-14	3425.88		6759.42	
O-3	- E-5	-14173.5		14509.7	
O-3	- E-7	826.478		10368.5	
O-3	- GS-13	3825.68		5008.45	
O-3	- GM-15	-14173.5		14509.7	
O-3	- GG-13	5825.48		14509.7	
CONTRACT	- GS-11	0.21429		11509.2	
CONTRACT	- GS-14	0.00000		14354.5	
CONTRACT	- O-2	6999.80		11118.9	
CONTRACT	- GS-12	2000.17		10407.2	
CONTRACT	- GM-13	5200.10		10805.7	
CONTRACT	- GS-09	-4999.50		17580.6	
CONTRACT	- O-6	4999.75		12431.4	
CONTRACT	- GM-14	7599.90		12009.8	
CONTRACT	- E-5	-9999.50		17580.6	
CONTRACT	- E-7	5000.50		14354.5	
CONTRACT	- GS-13	7999.70		11118.9	
CONTRACT	- GM-15	-9999.50		17580.6	
CONTRACT	- GG-13	9999.50		17580.6	
GS-11	- GS-14	-0.21429		11509.2	
GS-11	- O-2	6999.59		7073.98	
GS-11	- GS-12	1999.95		5892.31	
GS-11	- GM-13	5199.89		6570.60	
GS-11	- GS-09	-4999.71		15345.6	
GS-11	- O-6	4999.54		8997.16	
GS-11	- GM-14	7599.69		8405.13	
GS-11	- E-5	-9999.71		15345.6	
GS-11	- E-7	5000.29		11509.2	
GS-11	- GS-13	7999.49		7073.98	*
GS-11	- GM-15	-9999.71		15345.6	
GS-11	- GG-13	9999.29		15345.6	
GS-14	- O-2	6999.80		11118.9	
GS-14	- GS-12	2000.17		10407.2	
GS-14	- GM-13	5200.10		10805.7	
GS-14	- GS-09	-4999.50		17580.6	
GS-14	- O-6	4999.75		12431.4	
GS-14	- GM-14	7599.90		12009.8	
GS-14	- E-5	-9999.50		17580.6	
GS-14	- E-7	5000.50		14354.5	
GS-14	- GS-13	7999.70		11118.9	
GS-14	- GM-15	-9999.50		17580.6	
GS-14	- GG-13	9999.50		17580.6	
O-2	- GS-12	-4999.63		5088.08	
O-2	- GM-13	-1799.70		5860.20	
O-2	- GS-09	-11999.3		15055.1	
O-2	- O-6	-2000.05		8492.24	
O-2	- GM-14	600.100		7862.28	

Table 94. Continued.

contrast		difference	+/- limits	
O-2	- E-5	-16999.3	15055.1	*
O-2	- E-7	-1999.30	11118.9	
O-2	- GS-13	999.900	6419.53	
O-2	- GM-15	-16999.3	15055.1	*
O-2	- GG-13	2999.70	15055.1	
GS-12	- GM-13	3199.93	4361.21	
GS-12	- GS-09	-6999.67	14537.4	
GS-12	- O-6	2999.58	7536.33	
GS-12	- GM-14	5599.73	6818.63	
GS-12	- E-5	-11999.7	14537.4	
GS-12	- E-7	3000.33	10407.2	
GS-12	- GS-13	5999.53	5088.08	*
GS-12	- GM-15	-11999.7	14537.4	
GS-12	- GG-13	7999.33	14537.4	
GM-13	- GS-09	-10199.6	14825.3	
GM-13	- O-6	-200.350	8077.73	
GM-13	- GM-14	2399.80	7412.63	
GM-13	- E-5	-15199.6	14825.3	*
GM-13	- E-7	-199.600	10805.7	
GM-13	- GS-13	2799.60	5860.20	
GM-13	- GM-15	-15199.6	14825.3	*
GM-13	- GG-13	4799.40	14825.3	
GS-09	- O-6	9999.25	16048.8	
GS-09	- GM-14	12599.4	15724.6	
GS-09	- E-5	-5000.00	20300.3	
GS-09	- E-7	10000.0	17580.6	
GS-09	- GS-13	12999.2	15055.1	
GS-09	- GM-15	-5000.00	20300.3	
GS-09	- GG-13	14999.0	20300.3	
O-6	- GM-14	2600.15	9629.29	
O-6	- E-5	-14999.3	16048.8	
O-6	- E-7	0.75000	12431.4	
O-6	- GS-13	2999.95	8492.24	
O-6	- GM-15	-14999.3	16048.8	
O-6	- GG-13	4999.75	16048.8	
GM-14	- E-5	-17599.4	15724.6	*
GM-14	- E-7	-2599.40	12009.8	
GM-14	- GS-13	399.800	7862.28	
GM-14	- GM-15	-17599.4	15724.6	*
GM-14	- GG-13	2399.60	15724.6	
E-5	- E-7	15000.0	17580.6	
E-5	- GS-13	17999.2	15055.1	*
E-5	- GM-15	0.00000	20300.3	
E-5	- GG-13	19999.0	20300.3	
E-7	- GS-13	2999.20	11118.9	
E-7	- GM-15	-15000.0	17580.6	
E-7	- GG-13	4999.00	17580.6	
GS-13	- GM-15	-17999.2	15055.1	*

Table 94. Continued.

contrast		difference	+/- limits
GS-13	- GG-13	1999.80	15055.1
GM-15	- GG-13	19999.0	20300.3

* denotes a statistically significant difference.

Table 95. One-Way Analysis of Variance For Rank Versus Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	1.4861E0009	18	82561180	1.268	.2154
Within groups	1.0615E0010	163	65122085		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 96. Multiple Range Analysis For Rank Versus Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
O-2	10	54500.600	X
GG-13	1	55000.000	XX
O-6	4	56250.500	XX
O-3	46	57274.261	XXX
GM-14	5	57800.400	XXXX
GM-13	15	58533.600	XXXX
GS-12	39	59051.564	XXXX
O-4	26	60000.231	XXXX
O-5	6	60000.333	XXXX
CONTRACT	2	60000.500	XXXX
GS-13	10	61000.300	XXXX
O-1	3	63333.333	XXXX
GS-11	7	65000.000	X X
GS-09	1	65000.000	XXXX
E-7	2	65000.000	XXXX
E-4	1	70000.000	XXXX
GS-14	2	70000.000	X X
E-5	1	70000.000	XXXX
GM-15	1	70000.000	XXXX

Table 96. Continued.

contrast		difference +/-	limits
E-4	- O-4	9999.77	16242.0
E-4	- O-1	6666.67	18404.1
E-4	- O-5	9999.67	17215.5
E-4	- O-3	12725.7	16110.7
E-4	- CONTRACT	9999.50	19520.5
E-4	- GS-11	5000.00	17038.9
E-4	- GS-14	0.00000	19520.5
E-4	- O-2	15499.4	16716.4
E-4	- GS-12	10948.4	16141.5
E-4	- GM-13	11466.4	16461.1
E-4	- GS-09	5000.00	22540.3
E-4	- O-6	13749.5	17819.7
E-4	- GM-14	12199.6	17459.7
E-4	- E-5	0.00000	22540.3
E-4	- E-7	5000.00	19520.5
E-4	- GS-13	8999.70	16716.4
E-4	- GM-15	0.00000	22540.3
E-4	- GG-13	15000.0	22540.3
O-4	- O-1	-3333.10	9718.45
O-4	- O-5	-0.10256	7218.68
O-4	- O-3	2725.97	3910.62
O-4	- CONTRACT	-0.26923	11695.6
O-4	- GS-11	-4999.77	6786.82
O-4	- GS-14	-9999.77	11695.6
O-4	- O-2	5499.63	5930.75
O-4	- GS-12	948.667	4035.37
O-4	- GM-13	1466.63	5167.79
O-4	- GS-09	-4999.77	16242.0
O-4	- O-6	3749.73	8560.31
O-4	- GM-14	2199.83	7783.13
O-4	- E-5	-9999.77	16242.0
O-4	- E-7	-4999.77	11695.6
O-4	- GS-13	-1000.07	5930.75
O-4	- GM-15	-9999.77	16242.0
O-4	- GG-13	5000.23	16242.0
O-1	- O-5	3333.00	11270.2
O-1	- O-3	6059.07	9497.38
O-1	- CONTRACT	3332.83	14549.7
O-1	- GS-11	-1666.67	10998.6
O-1	- GS-14	-6666.67	14549.7
O-1	- O-2	8832.73	10492.0
O-1	- GS-12	4281.77	9549.42
O-1	- GM-13	4799.73	10080.3
O-1	- GS-09	-1666.67	18404.1
O-1	- O-6	7082.83	12173.2
O-1	- GM-14	5532.93	11639.8
O-1	- E-5	-6666.67	18404.1
O-1	- E-7	-1666.67	14549.7

Table 96. Continued.

contrast		difference	+/- limits	
O-1	- GS-13	2333.03	10492.0	
O-1	- GM-15	-6666.67	18404.1	
O-1	- GG-13	8333.33	18404.1	
O-5	- O-3	2726.07	6918.19	
O-5	- CONTRACT	-0.16667	13013.7	
O-5	- GS-11	-4999.67	8867.32	
O-5	- GS-14	-9999.67	13013.7	
O-5	- O-2	5499.73	8230.57	
O-5	- GS-12	948.769	6989.46	
O-5	- GM-13	1466.73	7698.99	
O-5	- GS-09	-4999.67	17215.5	
O-5	- O-6	3749.83	10288.2	
O-5	- GM-14	2199.93	9651.19	
O-5	- E-5	-9999.67	17215.5	
O-5	- E-7	-4999.67	13013.7	
O-5	- GS-13	-999.967	8230.57	
O-5	- GM-15	-9999.67	17215.5	
O-5	- GG-13	5000.33	17215.5	
O-3	- CONTRACT	-2726.24	11512.6	
O-3	- GS-11	-7725.74	6466.29	*
O-3	- GS-14	-12725.7	11512.6	*
O-3	- O-2	2773.66	5561.10	
O-3	- GS-12	-1777.30	3469.31	
O-3	- GM-13	-1259.34	4738.99	
O-3	- GS-09	-7725.74	16110.7	
O-3	- O-6	1023.76	8308.48	
O-3	- GM-14	-526.139	7505.27	
O-3	- E-5	-12725.7	16110.7	
O-3	- E-7	-7725.74	11512.6	
O-3	- GS-13	-3726.04	5561.10	
O-3	- GM-15	-12725.7	16110.7	
O-3	- GG-13	2274.26	16110.7	
CONTRACT	- GS-11	-4999.50	12779.2	
CONTRACT	- GS-14	-9999.50	15938.4	
CONTRACT	- O-2	5499.90	12345.8	
CONTRACT	- GS-12	948.936	11555.5	
CONTRACT	- GM-13	1466.90	11998.0	
CONTRACT	- GS-09	-4999.50	19520.5	
CONTRACT	- O-6	3750.00	13803.1	
CONTRACT	- GM-14	2200.10	13335.0	
CONTRACT	- E-5	-9999.50	19520.5	
CONTRACT	- E-7	-4999.50	15938.4	
CONTRACT	- GS-13	-999.800	12345.8	
CONTRACT	- GM-15	-9999.50	19520.5	
CONTRACT	- GG-13	5000.50	19520.5	
GS-11	- GS-14	-5000.00	12779.2	
GS-11	- O-2	10499.4	7854.54	*
GS-11	- GS-12	5948.44	6542.49	

Table 96. Continued.

contrast		difference	+/- limits	
GS-11	- GM-13	6466.40	7295.62	
GS-11	- GS-09	0.00000	17038.9	
GS-11	- O-6	8749.50	9989.93	
GS-11	- GM-14	7199.60	9332.58	
GS-11	- E-5	-5000.00	17038.9	
GS-11	- E-7	0.00000	12779.2	
GS-11	- GS-13	3999.70	7854.54	
GS-11	- GM-15	-5000.00	17038.9	
GS-11	- GG-13	10000.0	17038.9	
GS-14	- O-2	15499.4	12345.8	*
GS-14	- GS-12	10948.4	11555.5	
GS-14	- GM-13	11466.4	11998.0	
GS-14	- GS-09	5000.00	19520.5	
GS-14	- O-6	13749.5	13803.1	
GS-14	- GM-14	12199.6	13335.0	
GS-14	- E-5	0.00000	19520.5	
GS-14	- E-7	5000.00	15938.4	
GS-14	- GS-13	8999.70	12345.8	
GS-14	- GM-15	0.00000	19520.5	
GS-14	- GG-13	15000.0	19520.5	
O-2	- GS-12	-4550.96	5649.51	
O-2	- GM-13	-4033.00	6506.83	
O-2	- GS-09	-10499.4	16716.4	
O-2	- O-6	-1749.90	9429.30	
O-2	- GM-14	-3299.80	8729.83	
O-2	- E-5	-15499.4	16716.4	
O-2	- E-7	-10499.4	12345.8	
O-2	- GS-13	-6499.70	7127.88	
O-2	- GM-15	-15499.4	16716.4	
O-2	- GG-13	-499.400	16716.4	
GS-12	- GM-13	517.964	4842.44	
GS-12	- GS-09	-5948.44	16141.5	
GS-12	- O-6	2801.06	8367.91	
GS-12	- GM-14	1251.16	7571.02	
GS-12	- E-5	-10948.4	16141.5	
GS-12	- E-7	-5948.44	11555.5	
GS-12	- GS-13	-1948.74	5649.51	
GS-12	- GM-15	-10948.4	16141.5	
GS-12	- GG-13	4051.56	16141.5	
GM-13	- GS-09	-6466.40	16461.1	
GM-13	- O-6	2283.10	8969.05	
GM-13	- GM-14	733.200	8230.57	
GM-13	- E-5	-11466.4	16461.1	
GM-13	- E-7	-6466.40	11998.0	
GM-13	- GS-13	-2466.70	6506.83	
GM-13	- GM-15	-11466.4	16461.1	
GM-13	- GG-13	3533.60	16461.1	
GS-09	- O-6	8749.50	17819.7	

Table 96. Continued.

contrast		difference	+/- limits
GS-09	- GM-14	7199.60	17459.7
GS-09	- E-5	-5000.00	22540.3
GS-09	- E-7	0.00000	19520.5
GS-09	- GS-13	3999.70	16716.4
GS-09	- GM-15	-5000.00	22540.3
GS-09	- GG-13	10000.0	22540.3
O-6	- GM-14	-1549.90	10691.8
O-6	- E-5	-13749.5	17819.7
O-6	- E-7	-8749.50	13803.1
O-6	- GS-13	-4749.80	9429.30
O-6	- GM-15	-13749.5	17819.7
O-6	- GG-13	1250.50	17819.7
GM-14	- E-5	-12199.6	17459.7
GM-14	- E-7	-7199.60	13335.0
GM-14	- GS-13	-3199.90	8729.83
GM-14	- GM-15	-12199.6	17459.7
GM-14	- GG-13	2800.40	17459.7
E-5	- E-7	5000.00	19520.5
E-5	- GS-13	8999.70	16716.4
E-5	- GM-15	0.00000	22540.3
E-5	- GG-13	15000.0	22540.3
E-7	- GS-13	3999.70	12345.8
E-7	- GM-15	-5000.00	19520.5
E-7	- GG-13	10000.0	19520.5
GS-13	- GM-15	-8999.70	16716.4
GS-13	- GG-13	6000.30	16716.4
GM-15	- GG-13	15000.0	22540.3

* denotes a statistically significant difference.

Table 97. Years of Federal Employment Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	0 to 5	25	.1374	25	.137
2	6 to 10	43	.2363	68	.374
3	11 to 15	41	.2253	109	.599
4	16 to 20	34	.1868	143	.786
5	21 to 25	21	.1154	164	.901
6	26 to 30	12	.0659	176	.967
7	over 30	6	.0330	182	1.000

Table 98. Federal Employment One-Way Analysis of Variance - Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	1.8003E0008	6	30004477	.534	.7820
Within groups	9.8358E0009	175	56204568		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 99. Multiple Range Analysis For Federal Employment - Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
4	34	54882.912	X
7	6	55000.333	X
3	41	55000.512	X
1	25	55800.560	X
5	21	56048.143	X
2	43	56279.442	X
6	12	58833.750	X

contrast	difference	+/- limits
1 - 2	-478.882	3722.15
1 - 3	800.048	3755.38
1 - 4	917.648	3899.07
1 - 5	-247.583	4380.70
1 - 6	-3033.19	5197.38
1 - 7	800.227	6727.90
2 - 3	1278.93	3230.41
2 - 4	1396.53	3396.38
2 - 5	231.299	3939.95
2 - 6	-2554.31	4831.71
2 - 7	1279.11	6449.59
3 - 4	117.600	3432.76
3 - 5	-1047.63	3971.35
3 - 6	-3833.24	4857.35
3 - 7	0.17886	6468.83
4 - 5	-1165.23	4107.49
4 - 6	-3950.84	4969.28
4 - 7	-117.422	6553.29
5 - 6	-2785.61	5355.51
5 - 7	1047.81	6850.79
6 - 7	3833.42	7399.70

* denotes a statistically significant difference.

Table 100. Federal Employment One-Way Analysis of Variance - Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	2.3343E0008	6	38904904	.574	.7509
Within groups	1.1868E0010	175	67814695		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 101. Multiple Range Analysis For Federal Employment - Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
7	6	57833.500	X
1	25	58280.440	X
2	43	58363.047	X
4	34	58941.471	X
3	41	59122.220	X
6	12	61250.250	X
5	21	61571.714	X

contrast	difference	+/- limits
1 - 2	-82.6065	4088.56
1 - 3	-841.780	4125.06
1 - 4	-661.031	4282.89
1 - 5	-3291.27	4811.93
1 - 6	-2969.81	5709.01
1 - 7	446.940	7390.19
2 - 3	-759.173	3548.41
2 - 4	-578.424	3730.71
2 - 5	-3208.67	4327.79
2 - 6	-2887.20	5307.34
2 - 7	529.547	7084.49
3 - 4	180.749	3770.68
3 - 5	-2449.49	4362.29
3 - 6	-2128.03	5335.51
3 - 7	1288.72	7105.62
4 - 5	-2630.24	4511.83
4 - 6	-2308.78	5458.45
4 - 7	1107.97	7198.39
5 - 6	321.464	5882.70
5 - 7	3738.21	7525.18
6 - 7	3416.75	8128.12

* denotes a statistically significant difference.

Table 102. Gender Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	Female	34	.187	34	.187
2	Male	148	.813	182	1.000

Table 103. Gender One-Way Analysis of Variance For Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	2.5538E0008	1	2.5538E0008	4.710	.0313
Within groups	9.7604E0009	180	5.4225E0007		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 104. Gender Multiple Range Analysis For Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
Male	148	55196.459	X
Female	34	58235.647	X

contrast	difference	+/- limits
Male - Female	-3039.19	2764.00 *

* denotes a statistically significant difference.

Table 105. Gender One-Way Analysis of Variance For Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	3.4969E0007	1	34968614	.522	.4788
Within groups	1.2066E0010	180	67033513		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 106. Gender Multiple Range Analysis For Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
Male	148	58963.824	X
Female	34	60088.441	X

contrast	difference	+/- limits
Male - Female	-1124.62	3073.16

* denotes a statistically significant difference.

Table 107. Educational Background Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	High School Graduate	2	.0110	2	.0110
2	Some College	13	.0714	15	.0824
3	Associate Degree	8	.0440	23	.1264
4	Bachelors Degree	51	.2802	74	.4066
5	Some Grad Courses	36	.1978	110	.6044
6	Masters Degree	70	.3846	180	.9890
7	Doctoral Degree	2	.0110	182	1.0000

Table 108. Education Level One-Way Analysis of Variance For Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	4.0896E0008	6	68159303	1.242	.2873
Within groups	9.6069E0009	175	54896403		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 109. Multiple Range Analysis For Education Level Versus Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
7	2	50001.000	X
1	2	55000.500	XX
6	70	55071.971	XXX
2	13	55384.923	XXXX
5	36	55722.722	XXXXX
4	51	56137.686	XXXXX
3	8	61875.375	X X X

contrast	difference	+/- limits	
1 - 2	-384.423	11109.4	
1 - 3	-6874.88	11563.0	
1 - 4	-1137.19	10543.1	
1 - 5	-722.222	10625.7	
1 - 6	-71.4714	10489.0	
1 - 7	4999.50	14626.2	
2 - 3	-6490.45	6572.39	
2 - 4	-752.763	4544.26	
2 - 5	-337.799	4732.66	
2 - 6	312.952	4417.22	
2 - 7	5383.92	11109.4	
3 - 4	5737.69	5561.94	*
3 - 5	6152.65	5716.90	*
3 - 6	6803.40	5458.63	*
3 - 7	11874.4	11563.0	*
4 - 5	414.964	3183.86	
4 - 6	1065.71	2692.71	
4 - 7	6136.69	10543.1	
5 - 6	650.751	2999.74	
5 - 7	5721.72	10625.7	
6 - 7	5070.97	10489.0	

* denotes a statistically significant difference.

Table 110. Education Level One-Way Analysis of Variance For Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	4.5449E0008	6	75748766	1.138	.3421
Within groups	1.1647E0010	175	66551477		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 111. Multiple Range Analysis For Education Level Versus Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
1	2	50001.000	X
7	2	57500.500	XX
5	36	58139.278	XX
4	51	58472.863	XX
2	13	59615.538	XX
6	70	59907.386	XX
3	8	63875.125	X

Contrast	difference	+/- limits	
1 - 2	-9614.54	12232.0	
1 - 3	-13874.1	12731.4	*
1 - 4	-8471.86	11608.5	
1 - 5	-8138.28	11699.4	
1 - 6	-9906.39	11548.9	
1 - 7	-7499.50	16104.1	
2 - 3	-4259.59	7236.53	
2 - 4	1142.68	5003.46	
2 - 5	1476.26	5210.90	
2 - 6	-291.847	4863.57	
2 - 7	2115.04	12232.0	
3 - 4	5402.26	6123.97	
3 - 5	5735.85	6294.59	
3 - 6	3967.74	6010.22	
3 - 7	6374.63	12731.4	
4 - 5	333.585	3505.59	
4 - 6	-1434.52	2964.80	
4 - 7	972.363	11608.5	
5 - 6	-1768.11	3302.86	
5 - 7	638.778	11699.4	
6 - 7	2406.89	11548.9	

* denotes a statistically significant difference.

Table 112. Professional Experience Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	Technical	23	.1264	23	.126
2	Contracts	23	.1264	46	.253
3	Support	26	.1429	72	.396
4	Managerial	68	.3736	140	.769
5	Engineering	16	.0879	156	.857
6	Other	10	.0549	166	.912
7	Scientific	3	.0165	169	.929
8	Operations	13	.0714	182	1.000

Table 113. Professional Experience One-Way Analysis of Variance For Company A.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	3.6683E0008	7	52404303	.945	.4733
Within groups	9.6490E0009	174	55454001		
Total (corrected)	1.0016E0010	181			

* denotes statistically significant level

Table 114. Multiple Range Analysis For Professional Experience Versus Company A.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
5	16	52063.188	X
7	3	53667.000	XX
3	26	55115.923	XX
6	10	55500.700	XX
4	68	55838.721	XX
2	23	56522.174	XX
1	23	57391.609	X
8	13	57692.692	X

Table 114. Continued.

contrast	difference	+/- limits	
1 - 2	869.435	4335.04	
1 - 3	2275.69	4208.14	
1 - 4	1552.89	3546.05	
1 - 5	5328.42	4785.76	*
1 - 6	1890.91	5568.46	
1 - 7	3724.61	9024.11	
1 - 8	-301.084	5101.03	
2 - 3	1406.25	4208.14	
2 - 4	683.453	3546.05	
2 - 5	4458.99	4785.76	
2 - 6	1021.47	5568.46	
2 - 7	2855.17	9024.11	
2 - 8	-1170.52	5101.03	
3 - 4	-722.798	3389.73	
3 - 5	3052.74	4671.11	
3 - 6	-384.777	5470.25	
3 - 7	1448.92	8963.84	
3 - 8	-2576.77	4993.63	
4 - 5	3775.53	4084.77	
4 - 6	338.021	4978.92	
4 - 7	2171.72	8672.74	
4 - 8	-1853.97	4449.99	
5 - 6	-3437.51	5926.10	
5 - 7	-1603.81	9249.08	
5 - 8	-5629.50	5489.21	*
6 - 7	1833.70	9677.28	
6 - 8	-2191.99	6183.50	
7 - 8	-4025.69	9416.08	

* denotes a statistically significant difference.

Table 115. Professional Experience One-Way Analysis of Variance For Company B.

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig Lvl
Between groups	2.6548E0008	7	37926056	.558	.7895
Within groups	1.1836E0010	174	68020222		
Total (corrected)	1.2101E0010	181			

* denotes statistically significant level

Table 116. Multiple Range Analysis For Professional Experience Versus Company B.

Method: 95 Percent LSD

Level	Count	Average	Homogeneous Groups
2	23	57587.217	X
5	16	58375.313	X
4	68	58853.265	X
8	13	59000.308	X
3	26	59273.385	X
1	23	60261.130	X
6	10	62500.100	X
7	3	63333.667	X

contrast	difference	+/- limits
1 - 2	2673.91	4801.16
1 - 3	987.746	4660.60
1 - 4	1407.87	3927.33
1 - 5	1885.82	5300.33
1 - 6	-2238.97	6167.20
1 - 7	-3072.54	9994.41
1 - 8	1260.82	5649.51
2 - 3	-1686.17	4660.60
2 - 4	-1266.05	3927.33
2 - 5	-788.095	5300.33
2 - 6	-4912.88	6167.20
2 - 7	-5746.45	9994.41
2 - 8	-1413.09	5649.51
3 - 4	420.120	3754.20
3 - 5	898.072	5173.36
3 - 6	-3226.72	6058.42
3 - 7	-4060.28	9927.65
3 - 8	273.077	5530.56
4 - 5	477.952	4523.97
4 - 6	-3646.84	5514.27
4 - 7	-4480.40	9605.26
4 - 8	-147.043	4928.46
5 - 6	-4124.79	6563.29
5 - 7	-4958.35	10243.6
5 - 8	-624.995	6079.42
6 - 7	-833.567	10717.8
6 - 8	3499.79	6848.37
7 - 8	4333.36	10428.5

* denotes a statistically significant difference.

Appendix I. Debriefing Questions Results

This Appendix contains descriptive statistics for questions 11 - 13 and 16. Term and variable definitions are in Appendix D.

Table 117. Difficulty of Instructions Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	No	4	.0220	4	.0220
2	Yes	178	.9780	182	1.0000

Table 118. Descriptive Statistics For Time Required To Make Loan Decisions and Level of Interest Frequency Tabulation.

Variable:	Time	Interest
Sample size	182	182
Average	1.81813	4.21429
Median	1	4
Mode	1	4
Variance	2.25779	2.36819
Standard deviation	1.50259	1.53889
Standard error	0.11138	0.11407
Minimum	0.1	1
Maximum	7	7
Range	6.9	6
Lower quartile	1	4
Upper quartile	2.5	5
Interquartile range	1.5	1

Table 119. Prior Knowledge of Experiment Frequency Tabulation.

Class	Lower Limit	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	No	182	1.00	182	1.00

Appendix J. Normality Plots

This appendix shows the Wilk-Shapiro/Rankit Plots and test statistics for Companies A and B in each of the 12 cells within the behavioral experiment. The value of the Wilk-Shapiro test statistic and the exact location of each of the plots is detailed in Table 120. Additionally, the Wilk-Shapiro test statistic for each of the ten perceptual questions (questions one through ten of the end-of-exercise questionnaire) is contained in Table 121.

Table 120. Wilk-Shapiro/Rankit Test Statistics and Location of Plots For Companies A and B For Cells 1 - 12.

Cell Number	Wilk-Shapiro Test Statistic Company A	Wilk-Shapiro Test Statistic Company B	Rankit Plot Page number
1	.7215	.8775	247-248
2	.8070	.8561	249-250
3	.9107	.8250	251-252
4	.8929	.8951	253-254
5	.8759	.6744	255-256
6	.8698	.8829	257-258
7	.8589	.7191	259-260
8	.7484	.5641	261-262
9	.4204	.8630	263-264
10	.5297	.8651	265-266
11	.4878	.9219	267-268
12	.5080	.8825	269-270

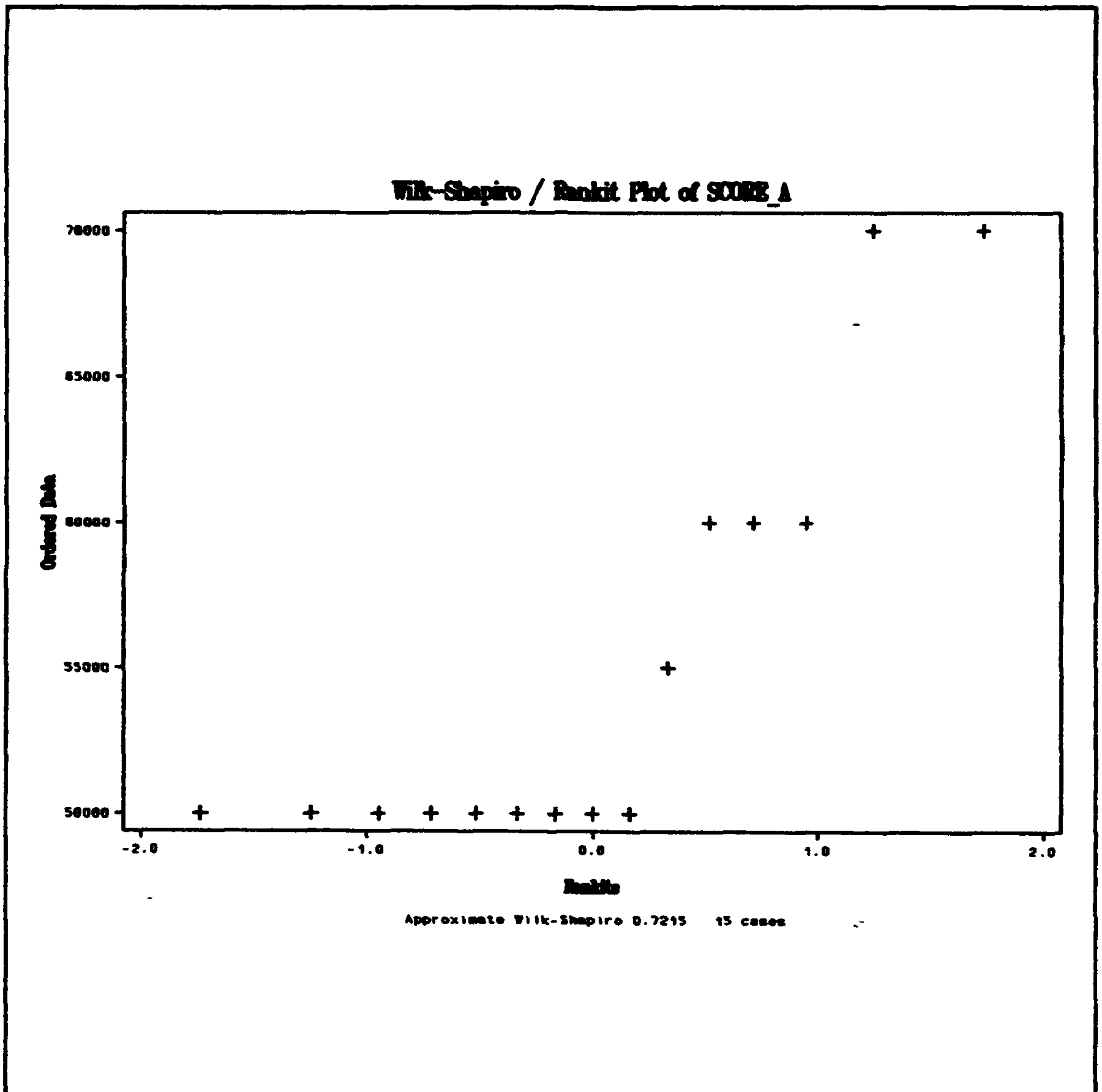


Figure 13. Wilk-Shapiro/Rankit Plot - Company A - Cell 1.

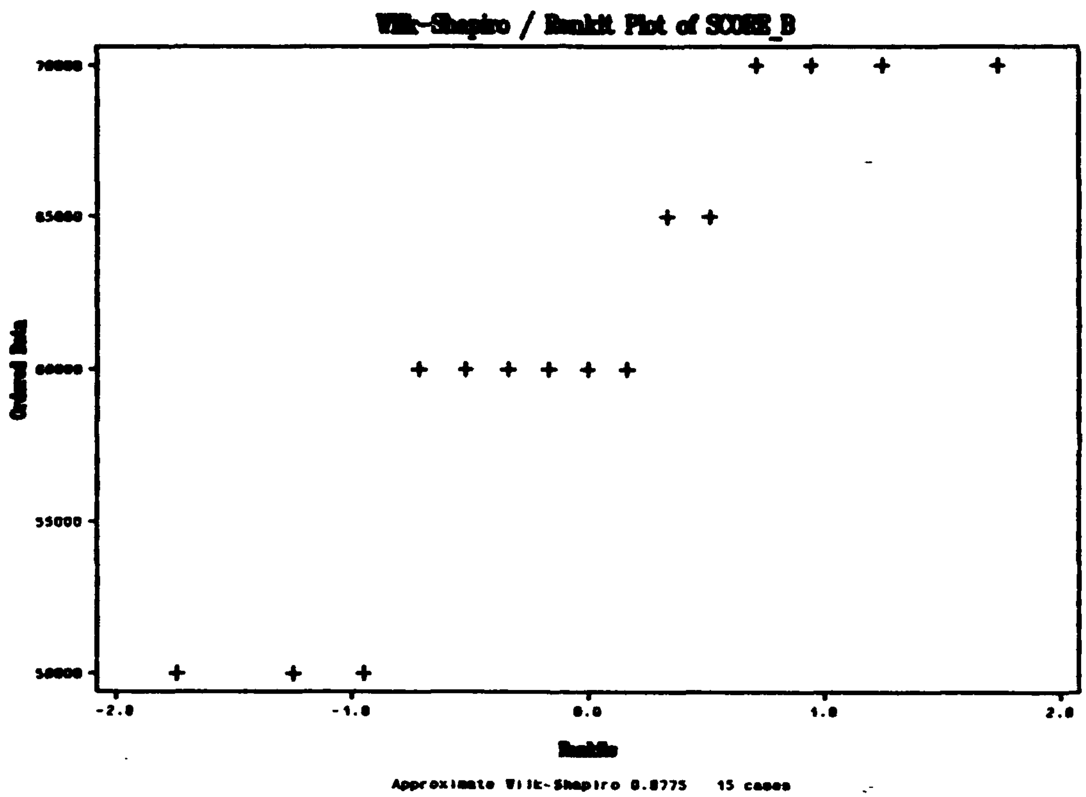


Figure 14. Wilk-Shapiro/Rankit Plot - Company B - Cell 1.

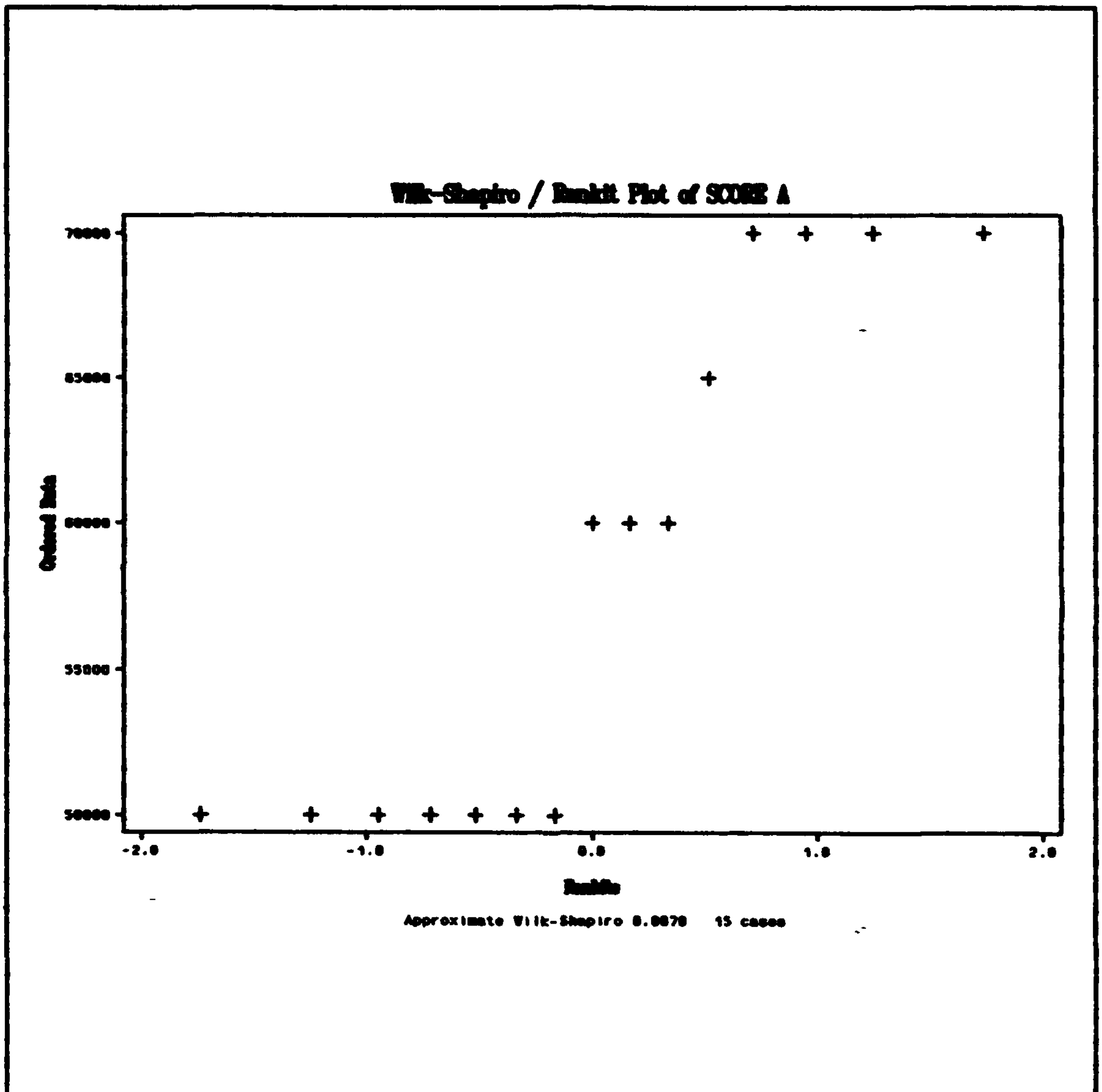


Figure 15. Wilk-Shapiro/Rankit Plot - Company A - Cell 2.

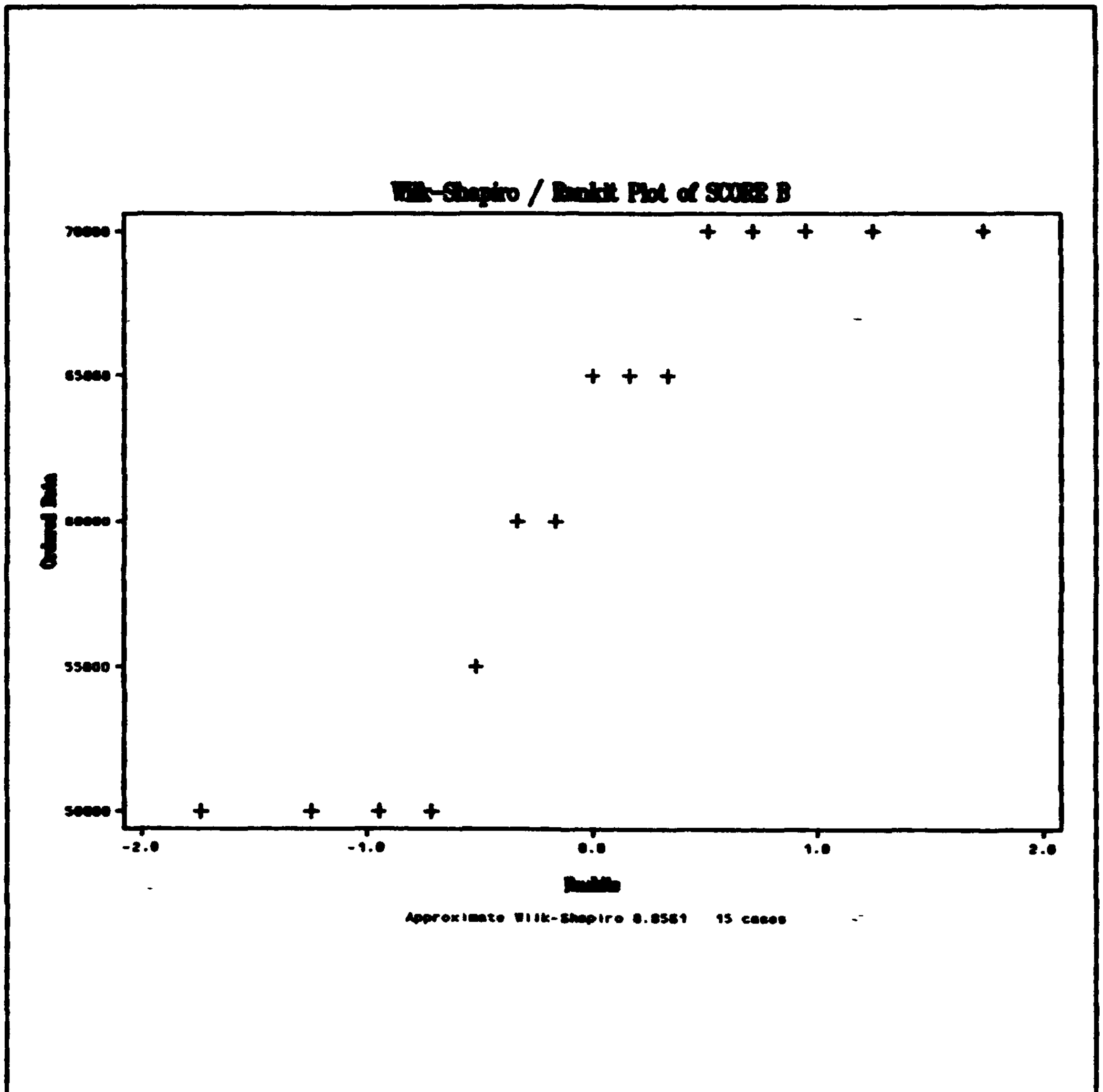


Figure 16. Wilk-Shapiro/Rankit Plot - Company B - Cell 2.

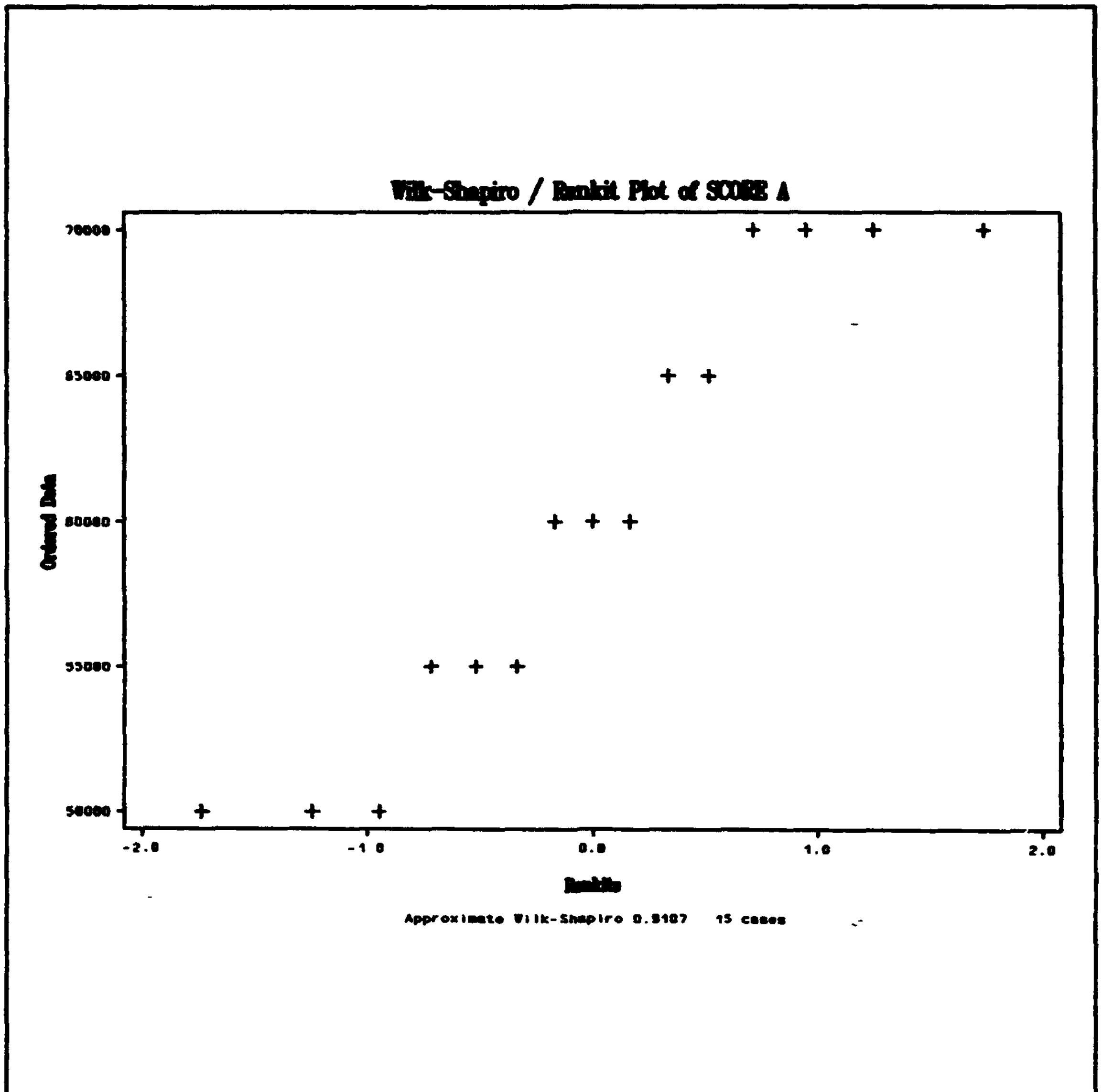


Figure 17. Wilk-Shapiro/Rankit Plot - Company A - Cell 3.

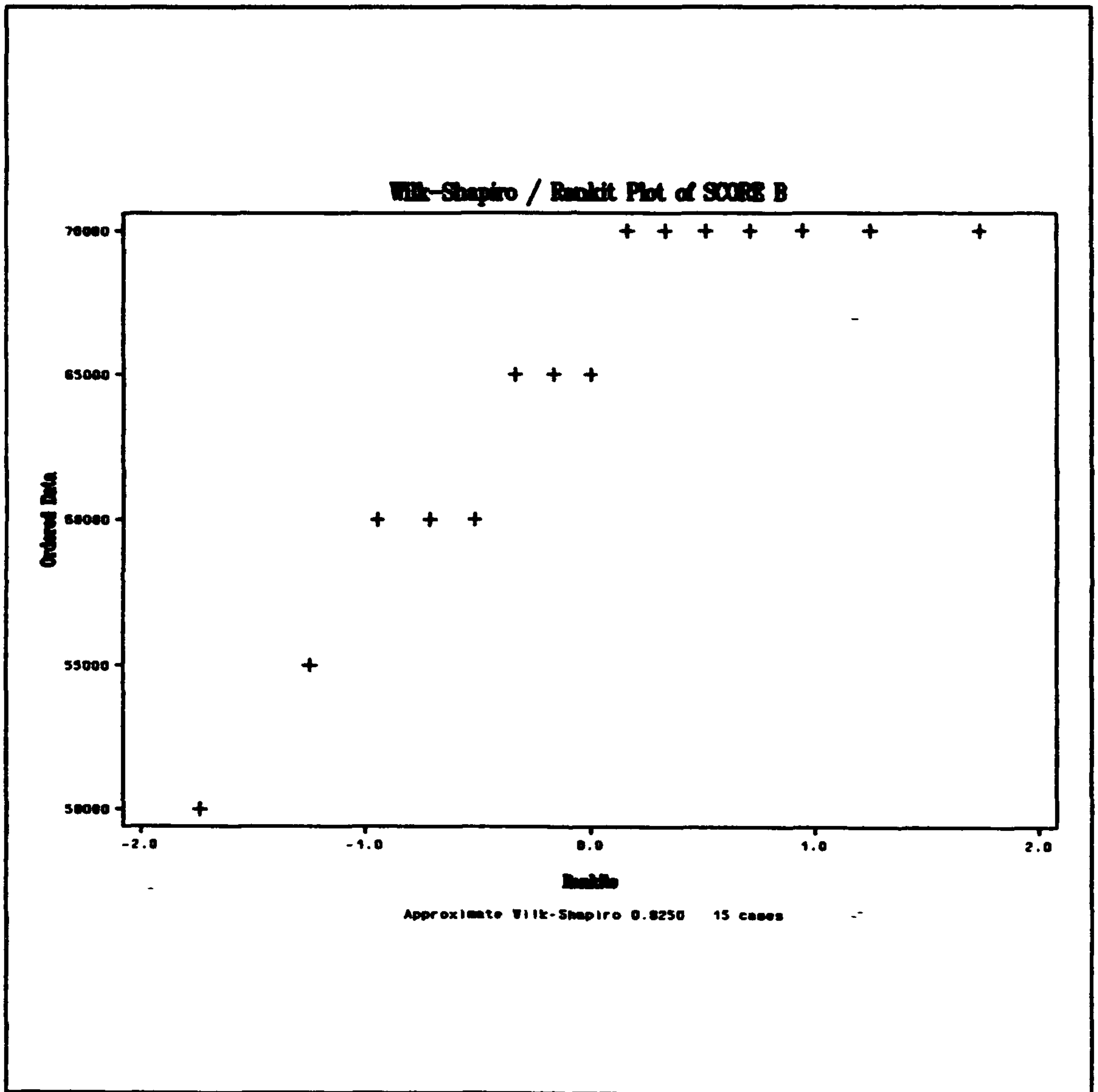


Figure 18. Wilk-Shapiro/Rankit Plot - Company B - Cell 3.

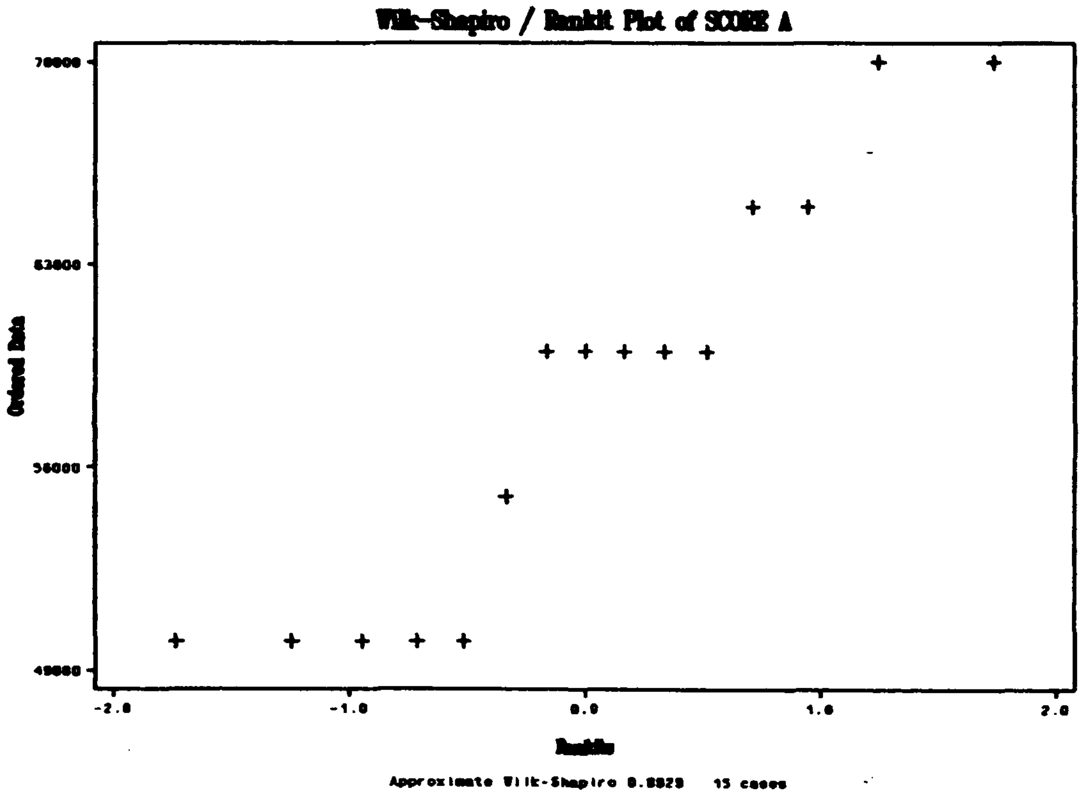


Figure 19. Wilk-Shapiro/Rankit Plot - Company A - Cell 4.

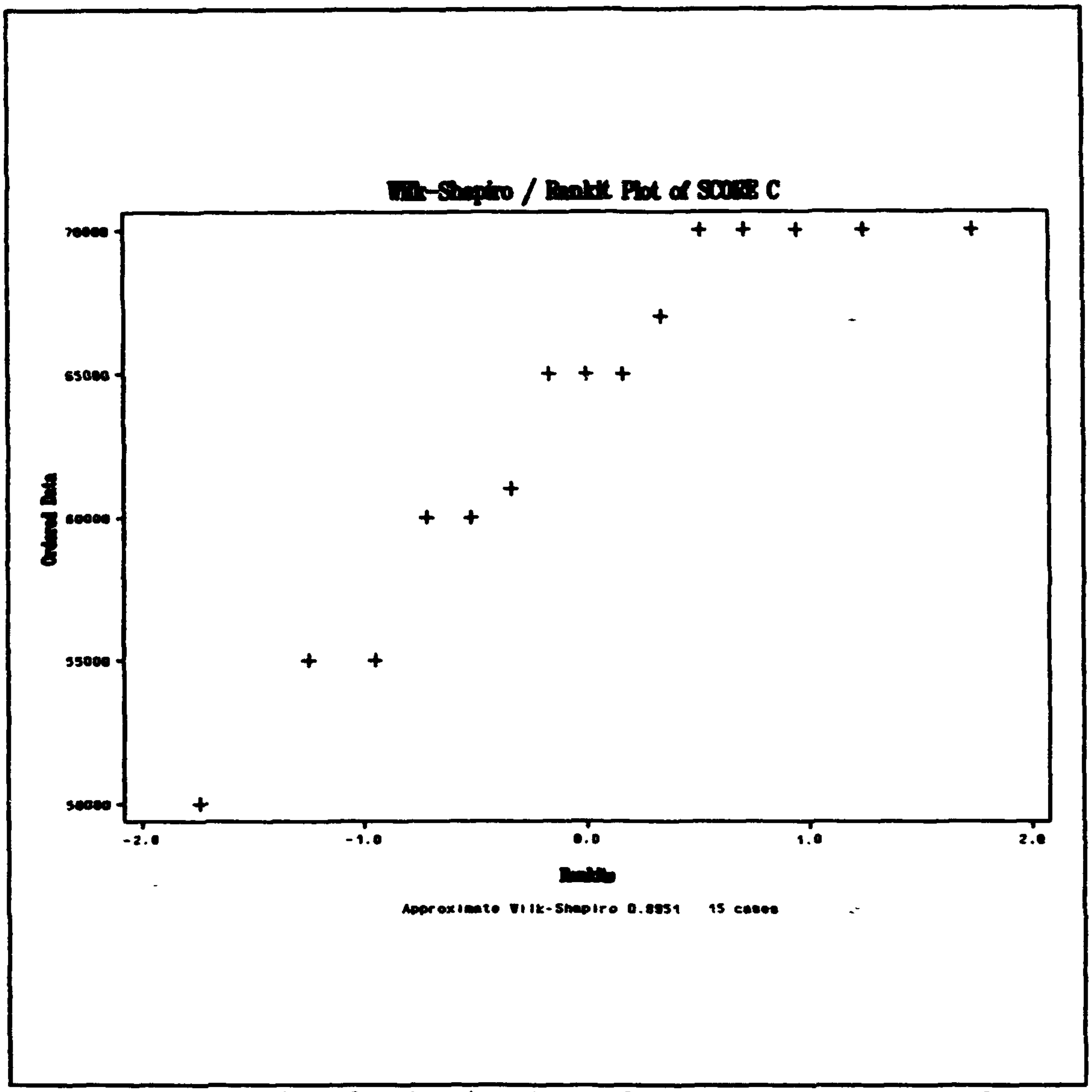


Figure 20. Wilk-Shapiro/Rankit Plot - Company B - Cell 4.

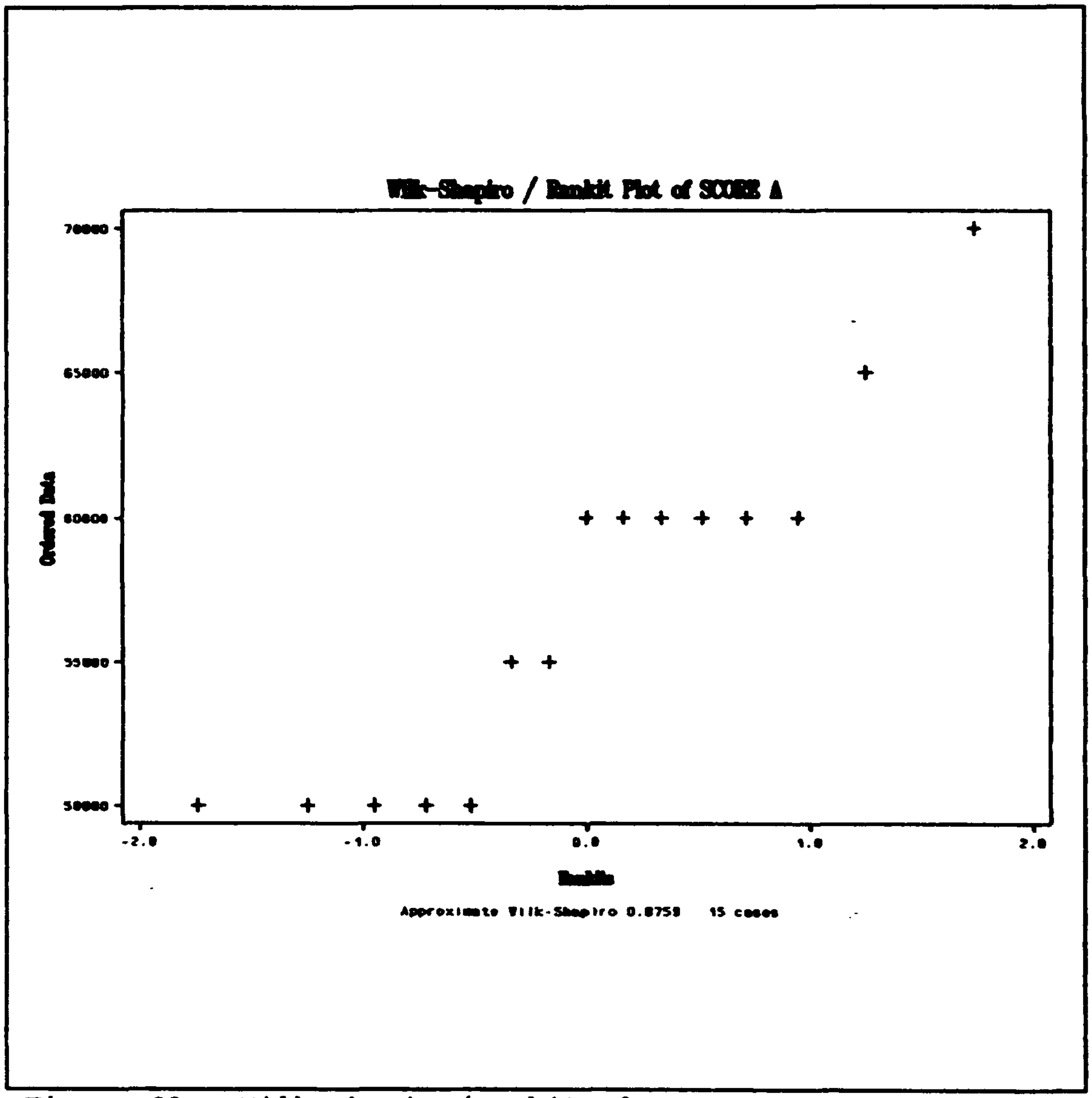


Figure 21. Wilk-Shapiro/Rankit Plot - Company A - Cell 5.

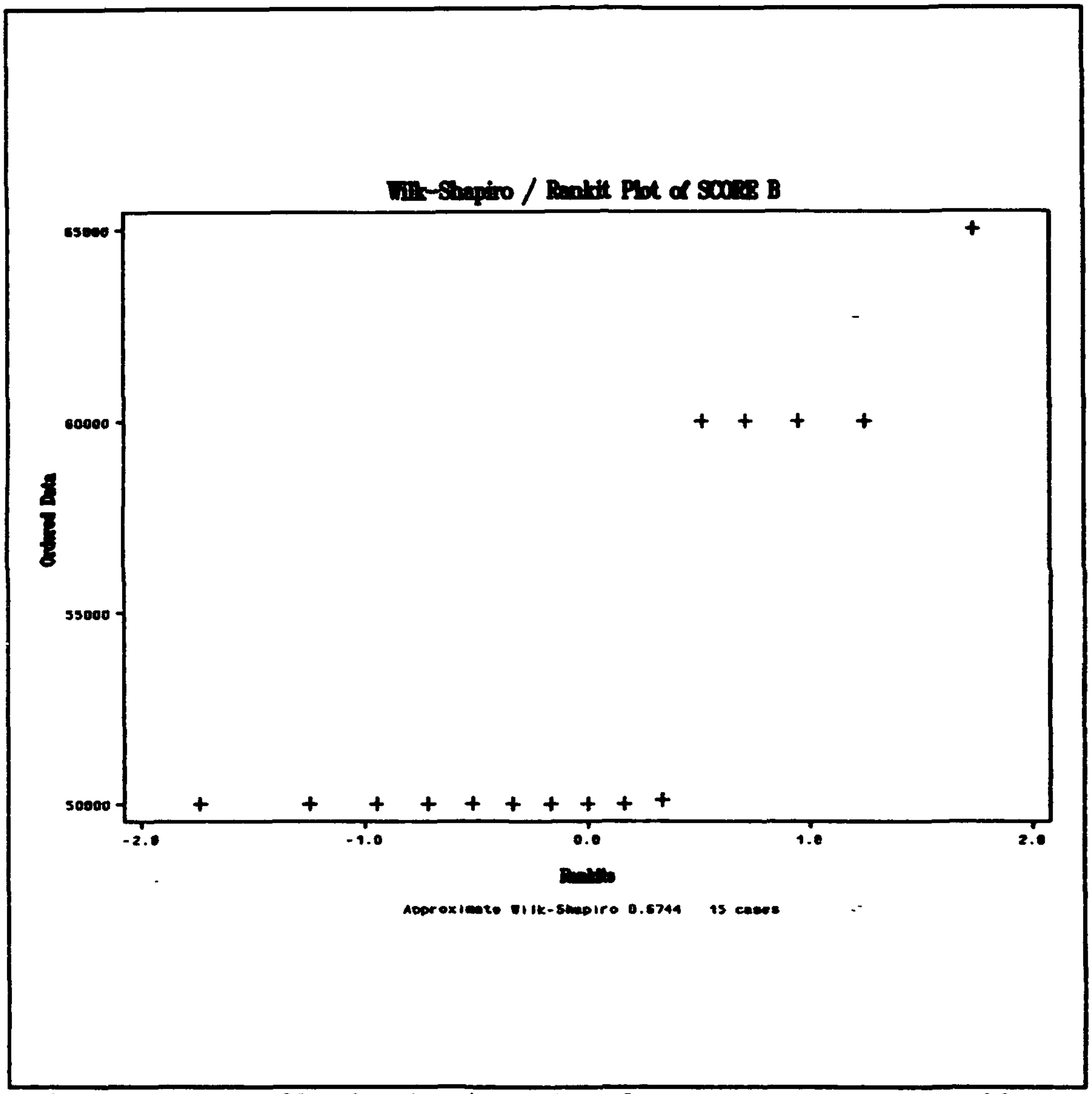


Figure 22. Wilk-Shapiro/Rankit Plot - Company B - Cell 5.

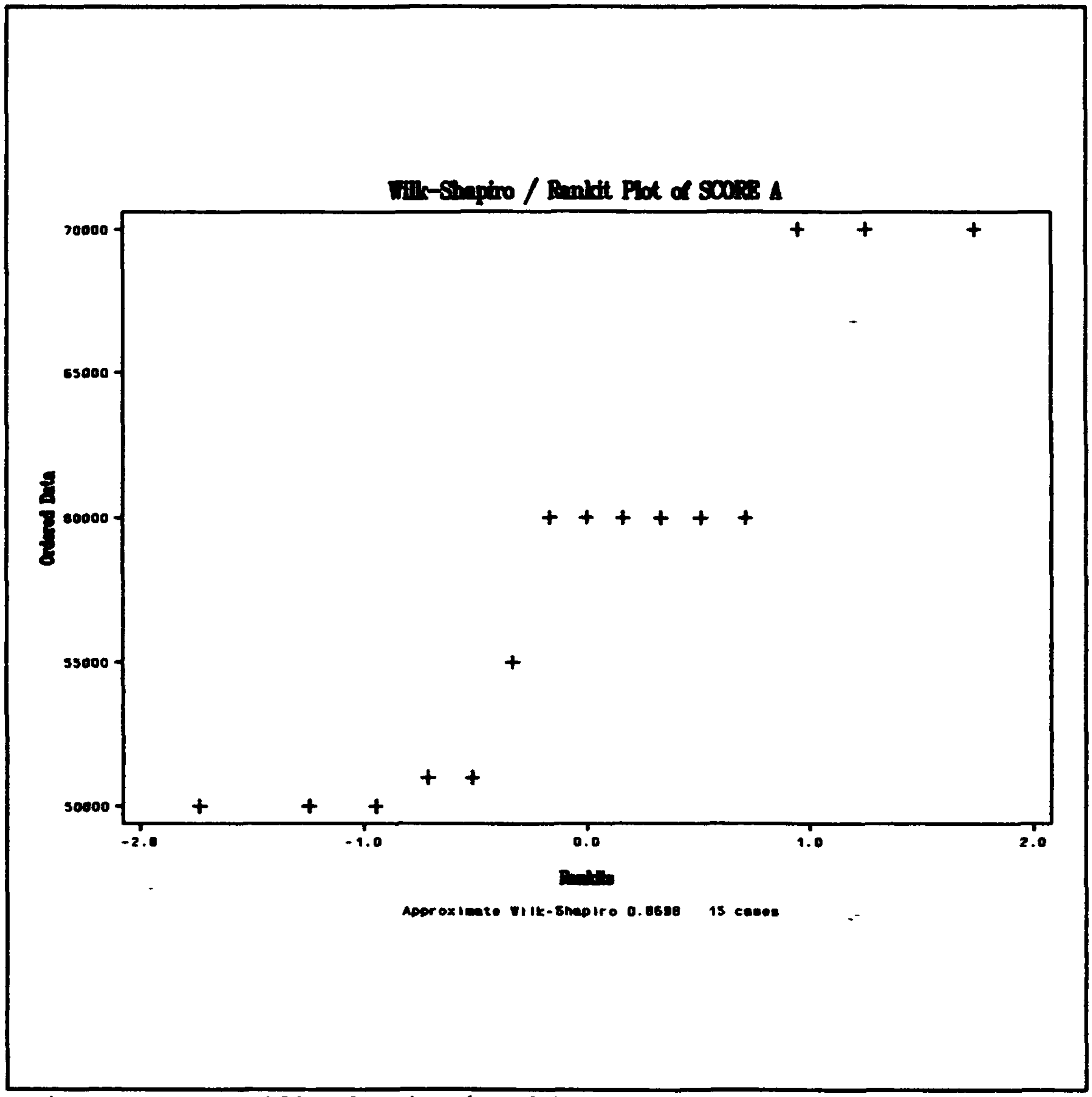


Figure 23. Wilk-Shapiro/Rankit Plot - Company A - Cell 6.

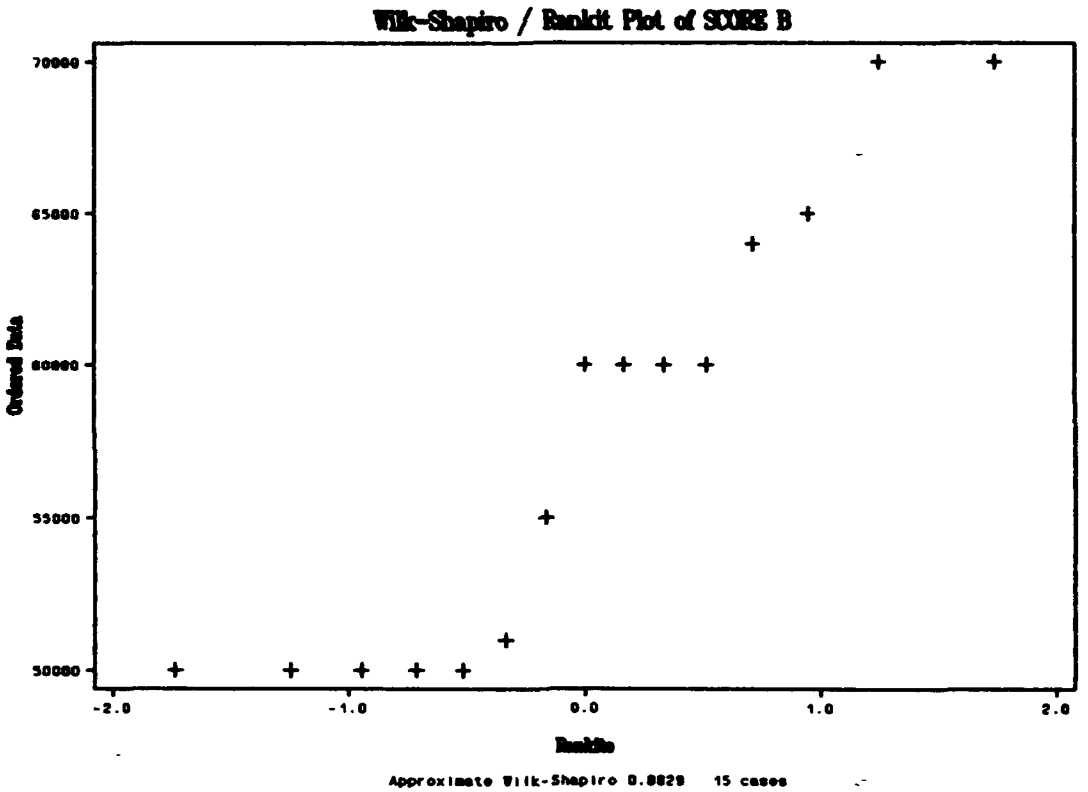


Figure 24. Wilk-Shapiro/Rankit Plot - Company B - Cell 6.

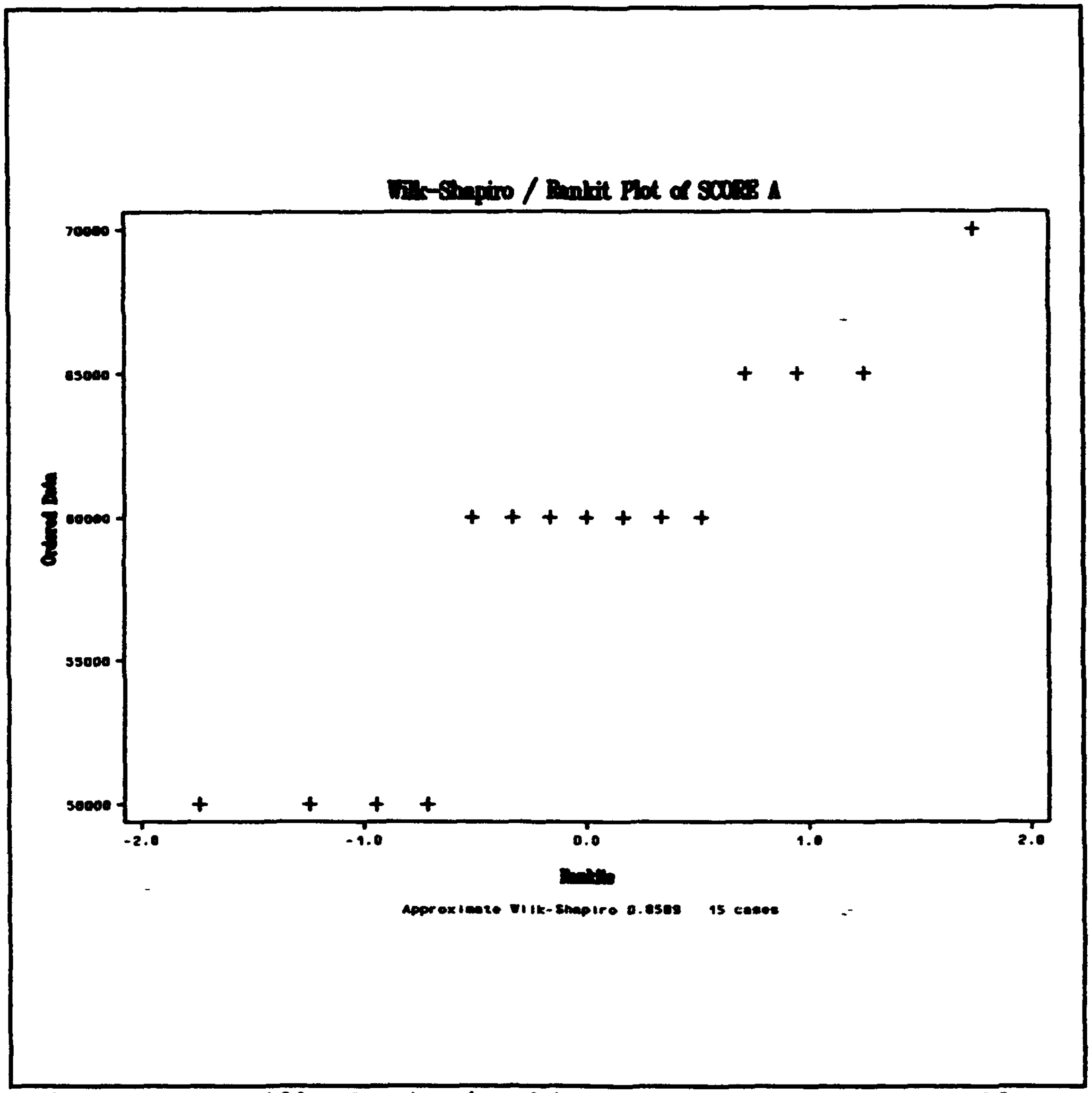


Figure 25. Wilk-Shapiro/Rankit Plot - Company A - Cell 7.

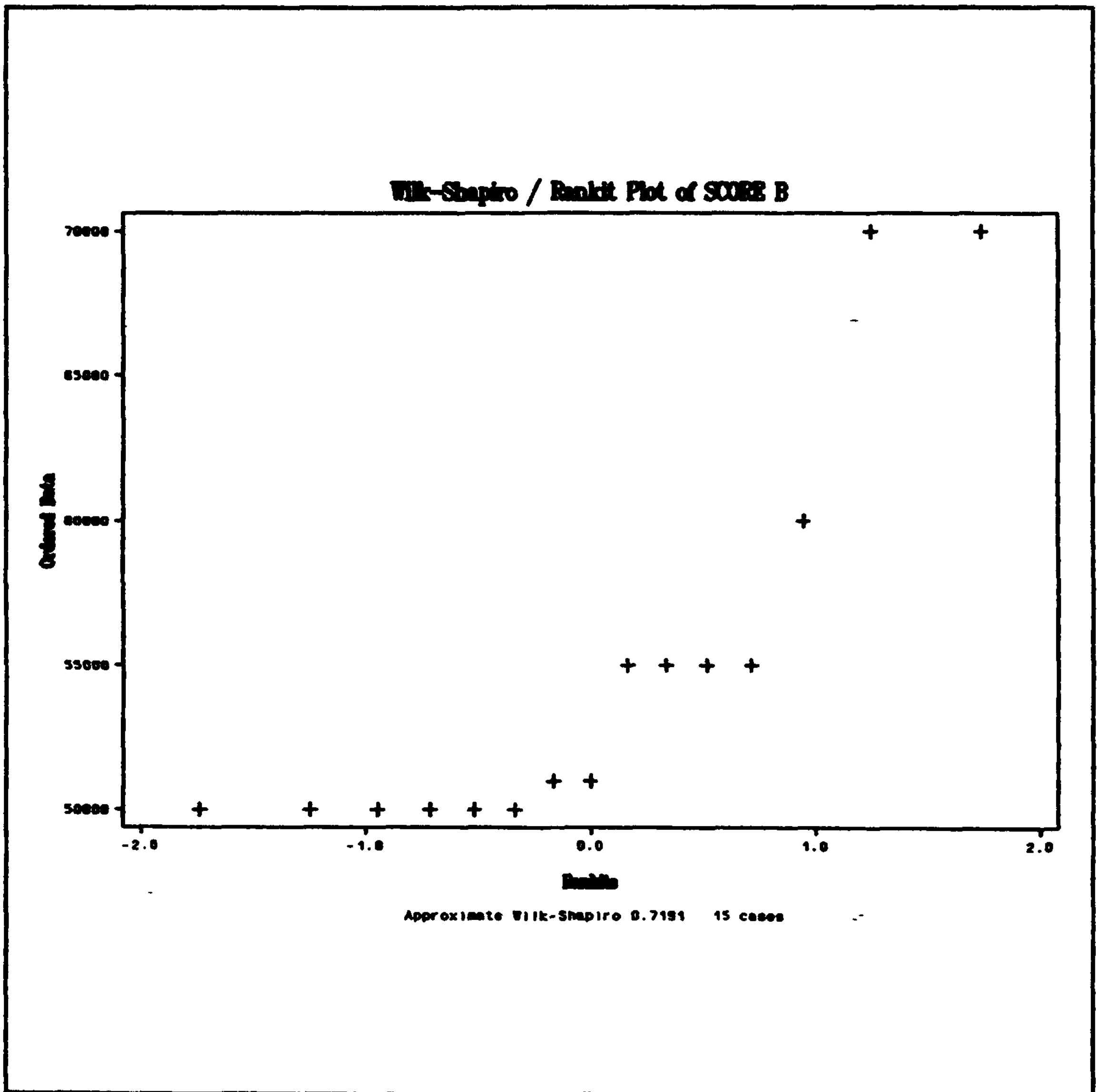


Figure 26. Wilk-Shapiro/Rankit Plot - Company B - Cell 7.

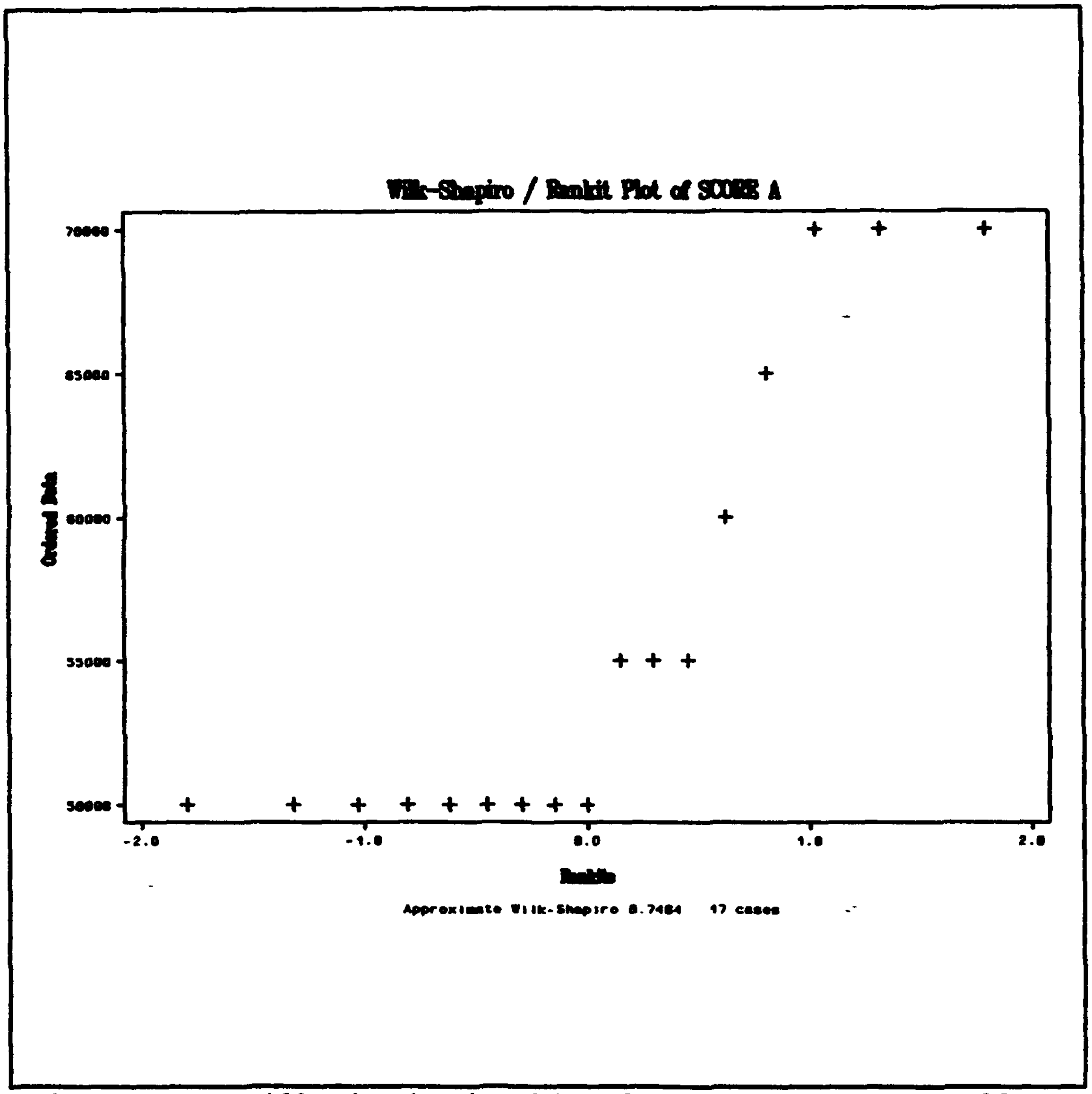


Figure 27. Wilk-Shapiro/Rankit Plot - Company A - Cell 8.

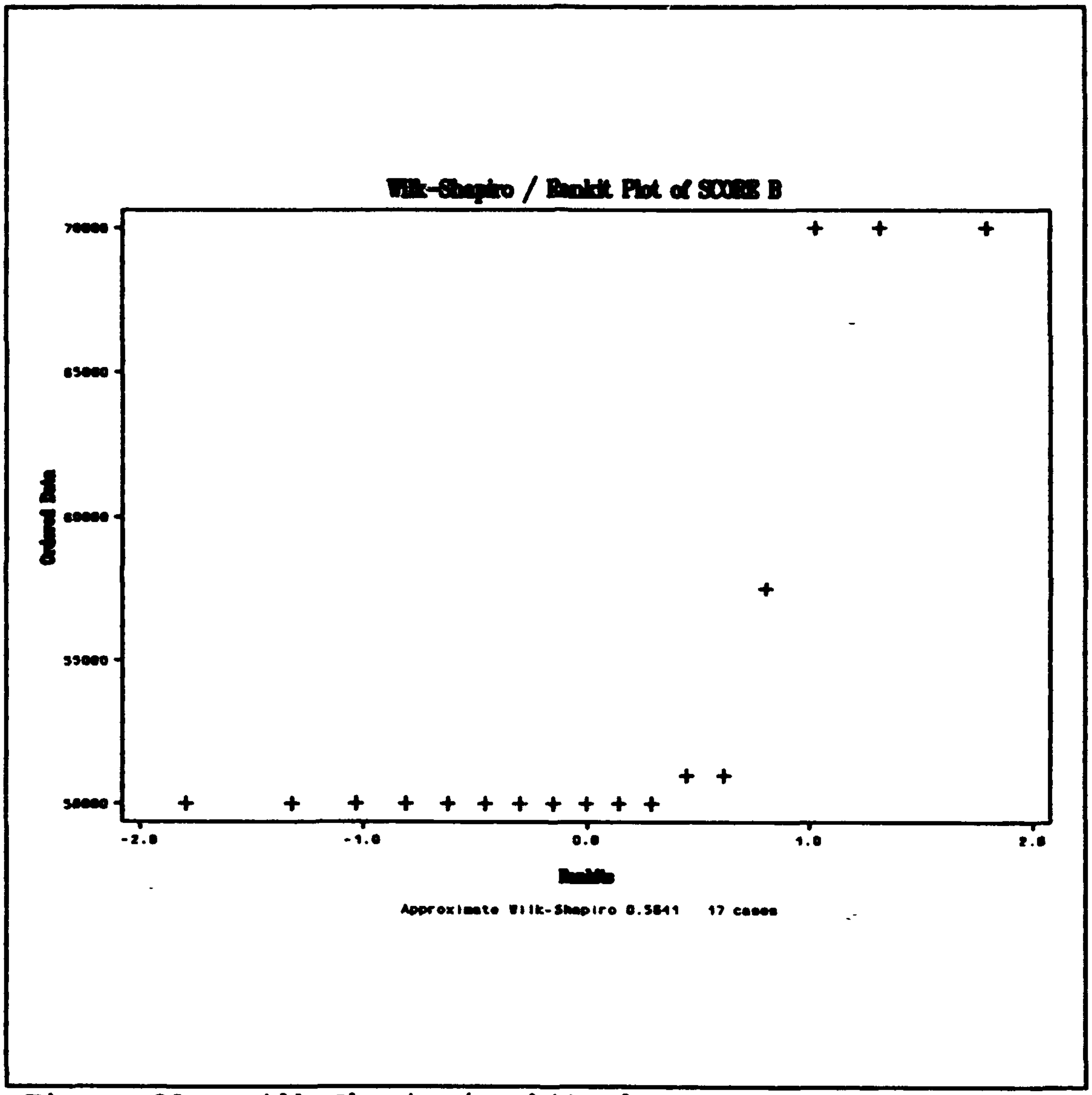


Figure 28. Wilk-Shapiro/Rankit Plot - Company B - Cell 8.

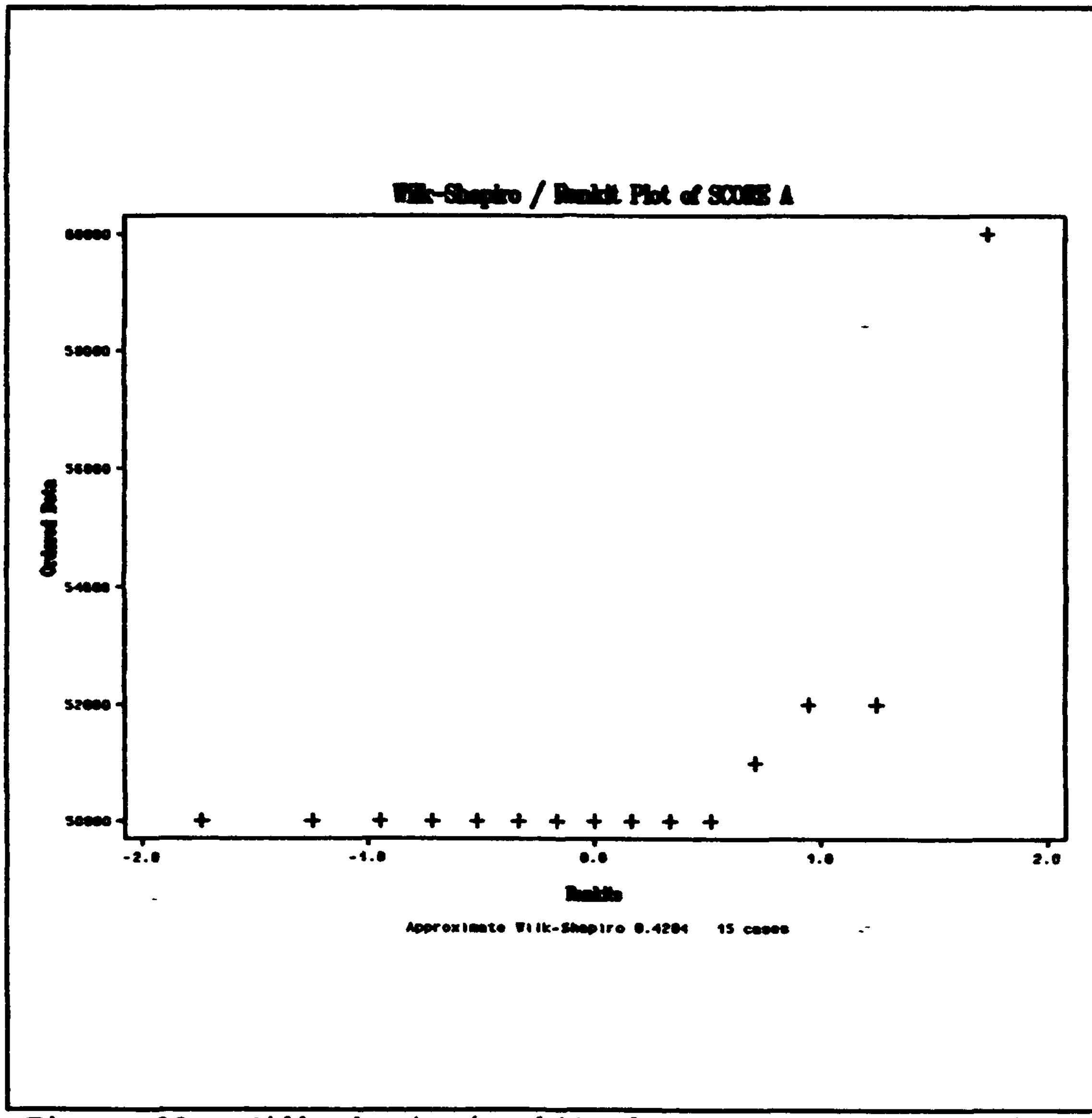


Figure 29. Wilk-Shapiro/Rankit Plot - Company A - Cell 9.

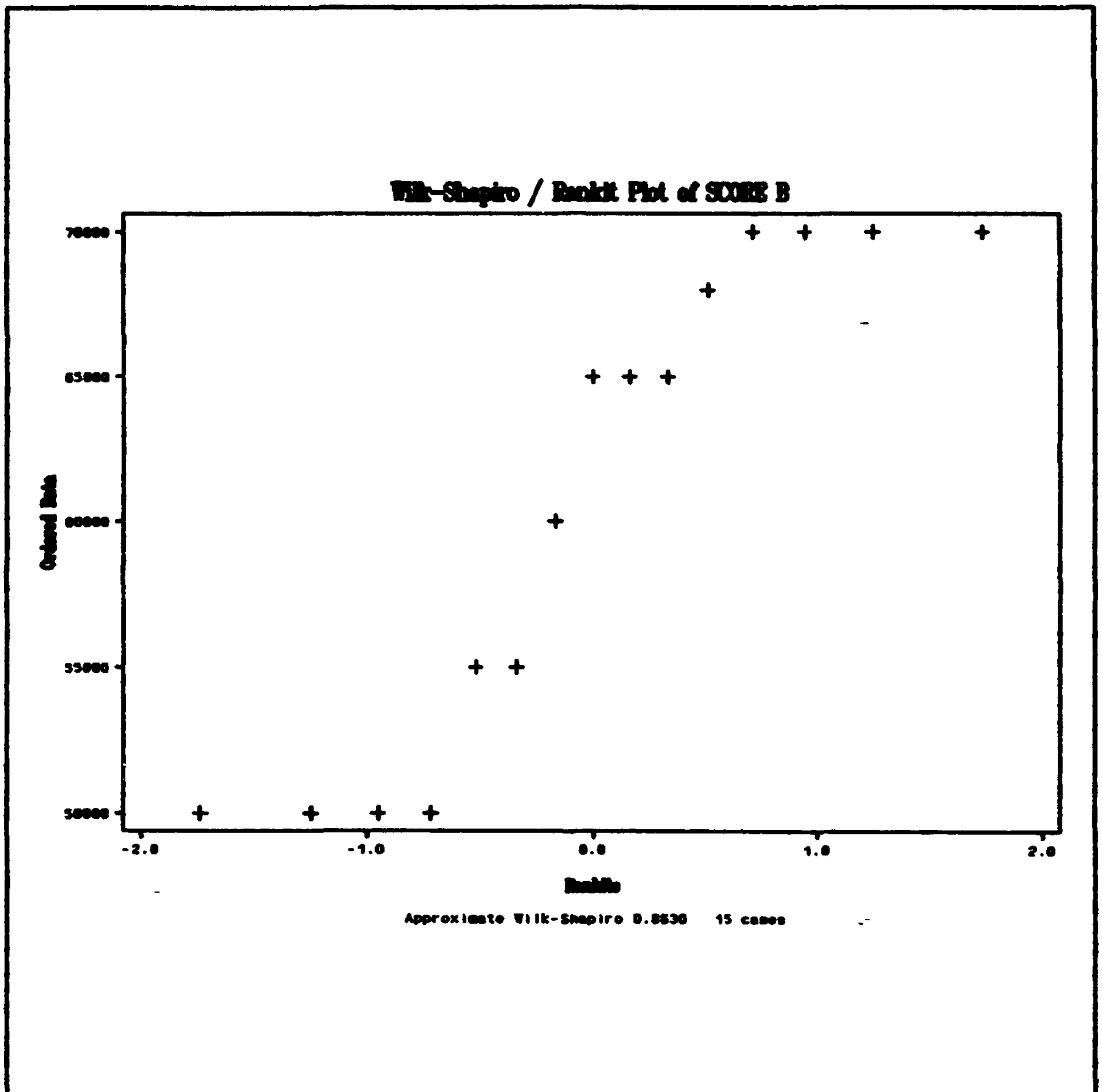


Figure 30. Wilk-Shapiro/Rankit Plot - Company B - Cell 9.

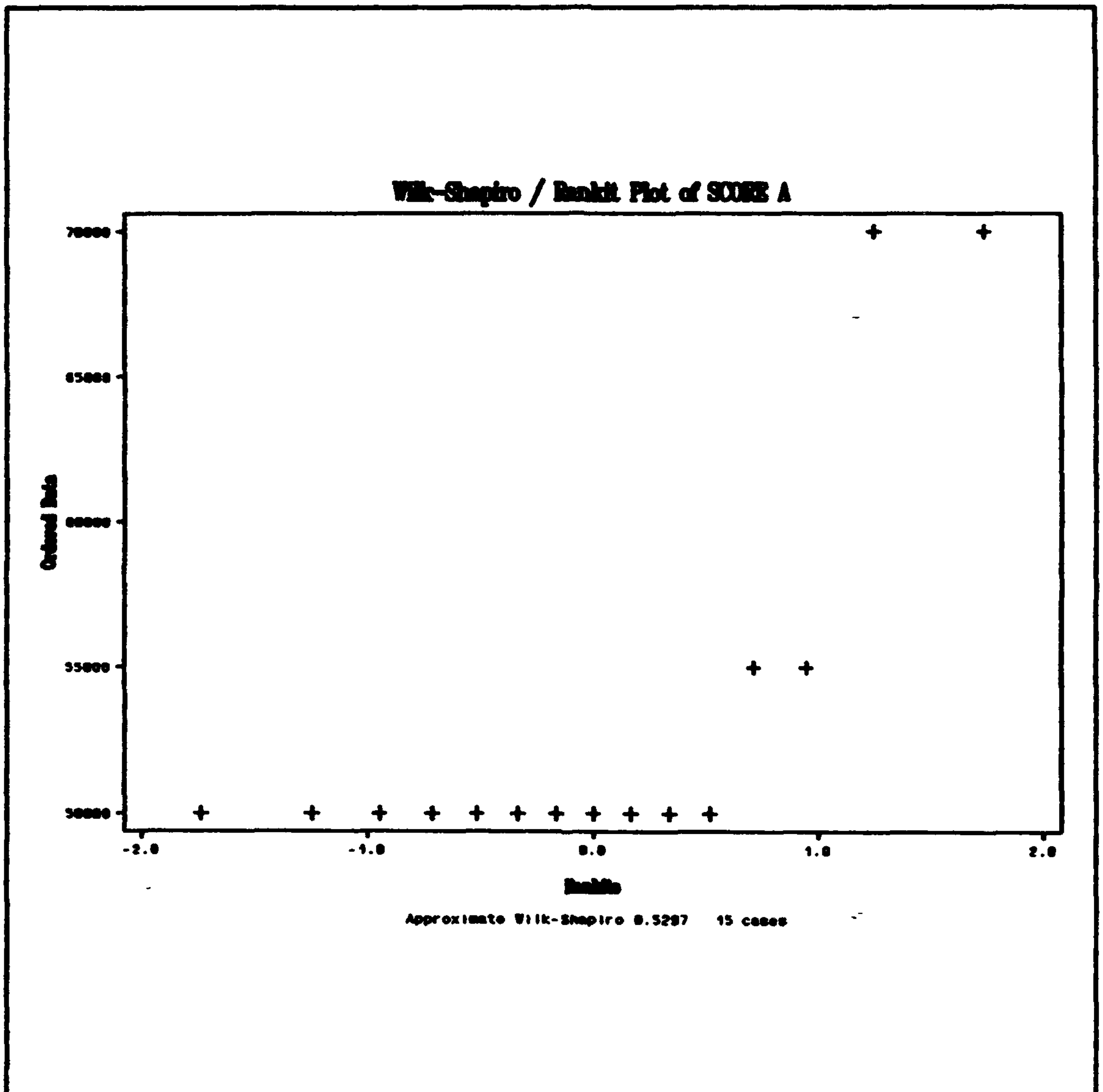


Figure 31. Wilk-Shapiro/Rankit Plot - Company A - Cell 10.

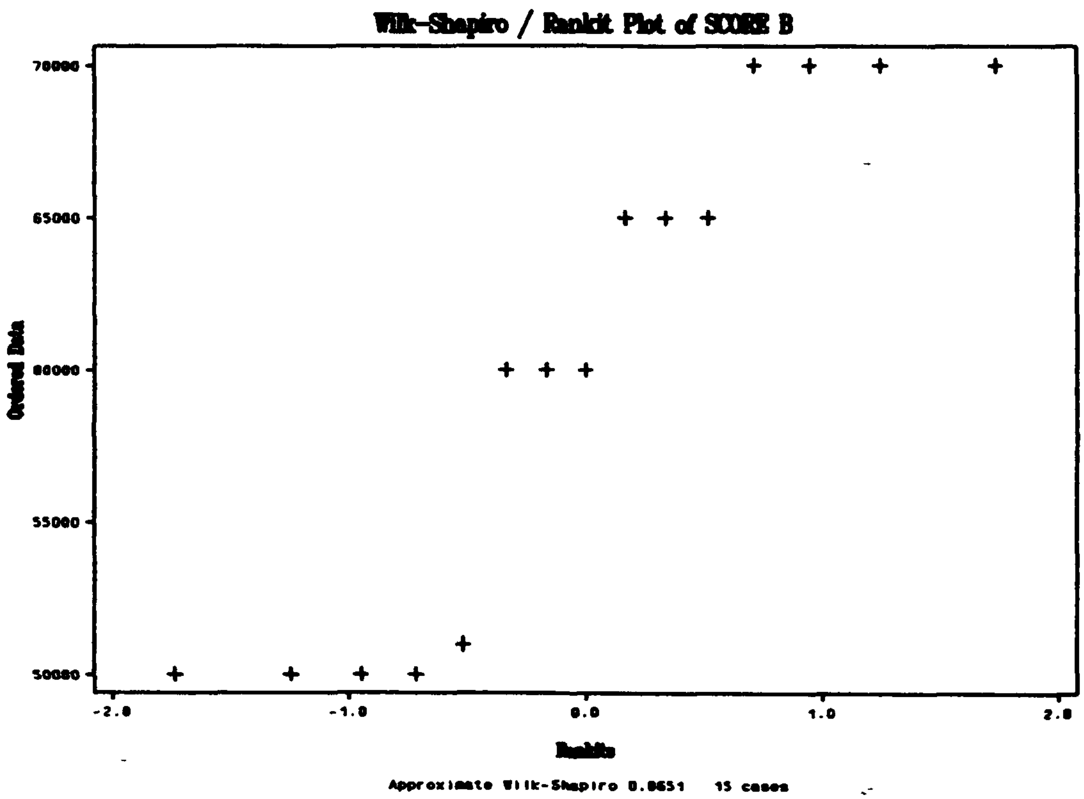


Figure 32. Wilk-Shapiro/Rankit Plot - Company B - Cell 10.

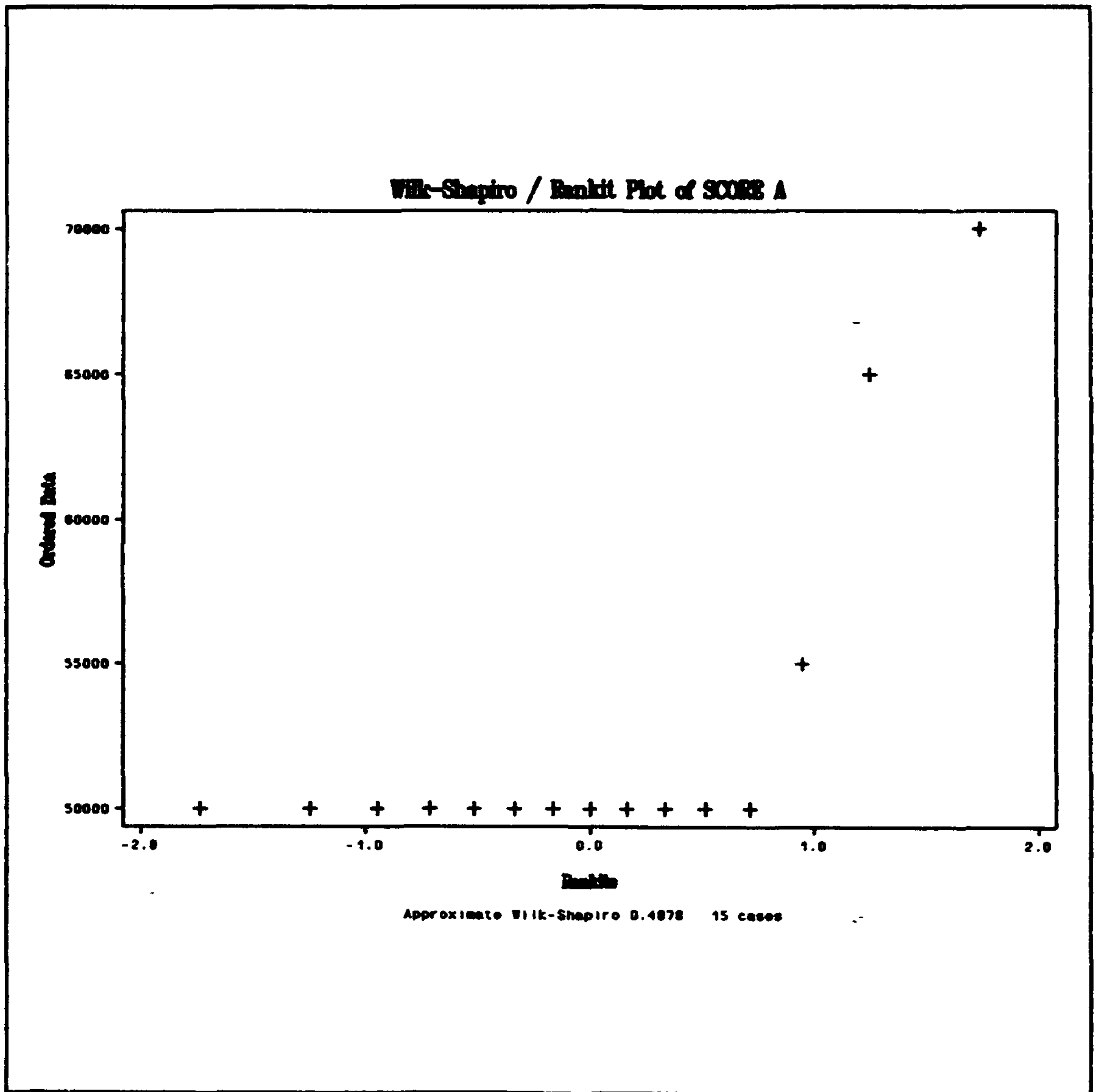


Figure 33. Wilk-Shapiro/Rankit Plot - Ccmpany A - Cell 11.

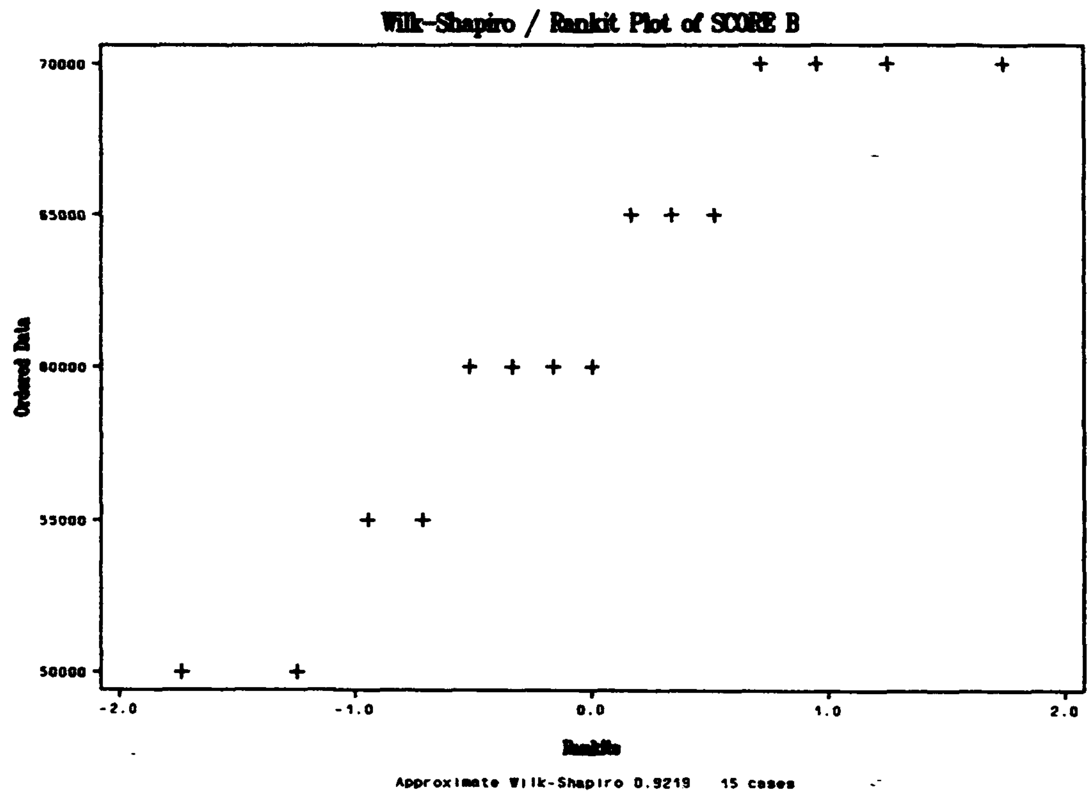


Figure 34. Wilk-Shapiro/Rankit Plot - Company B - Cell 11.

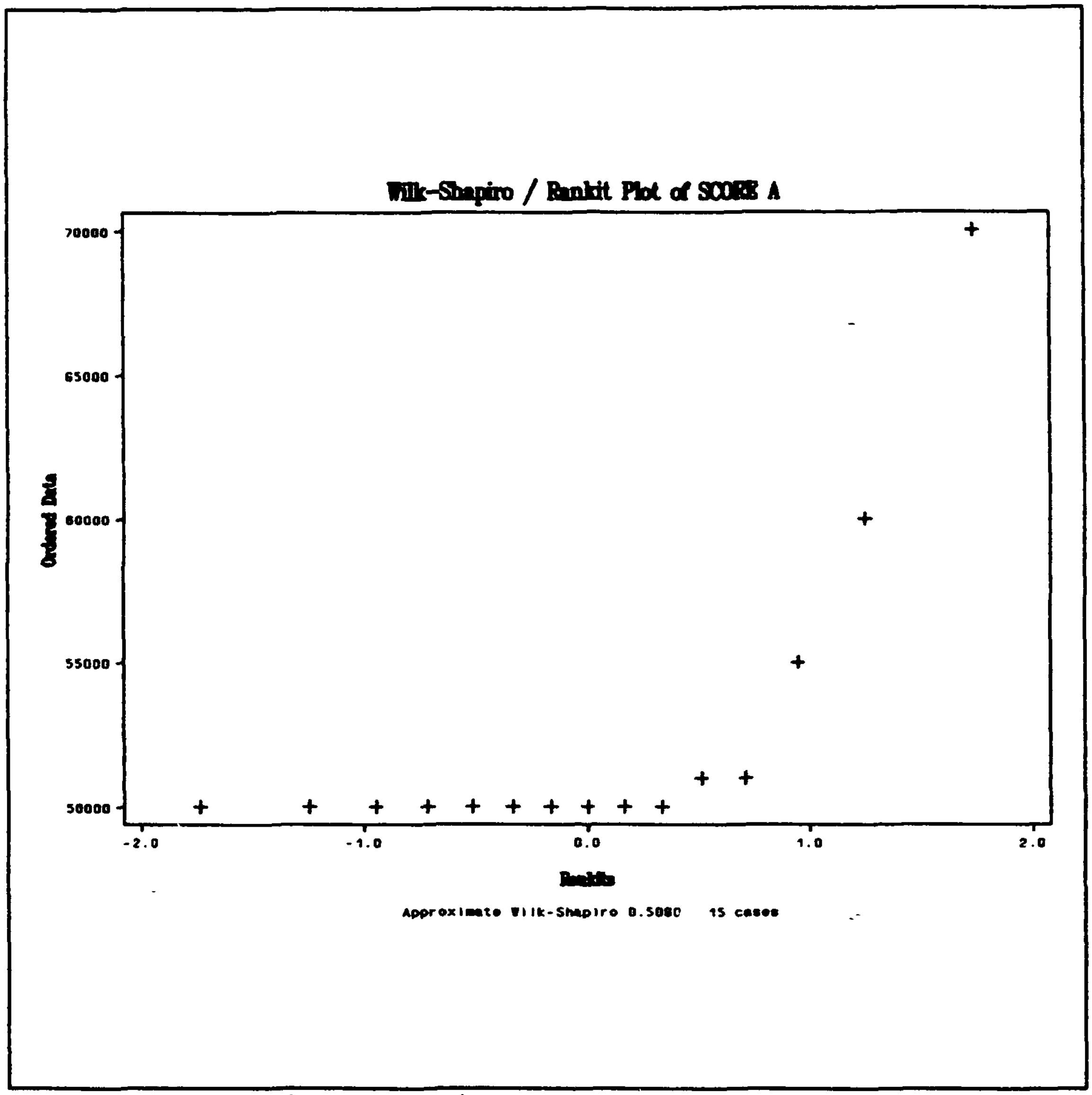


Figure 35. Wilk-Shapiro/Rankit Plot - Company A - Cell 12.

AD-A276 274 THE EFFECT OF FILL PATTERNS ON GRAPHICAL INTERPRETATION 4/4
AND DECISION MAKING(U) AIR FORCE INST OF TECH
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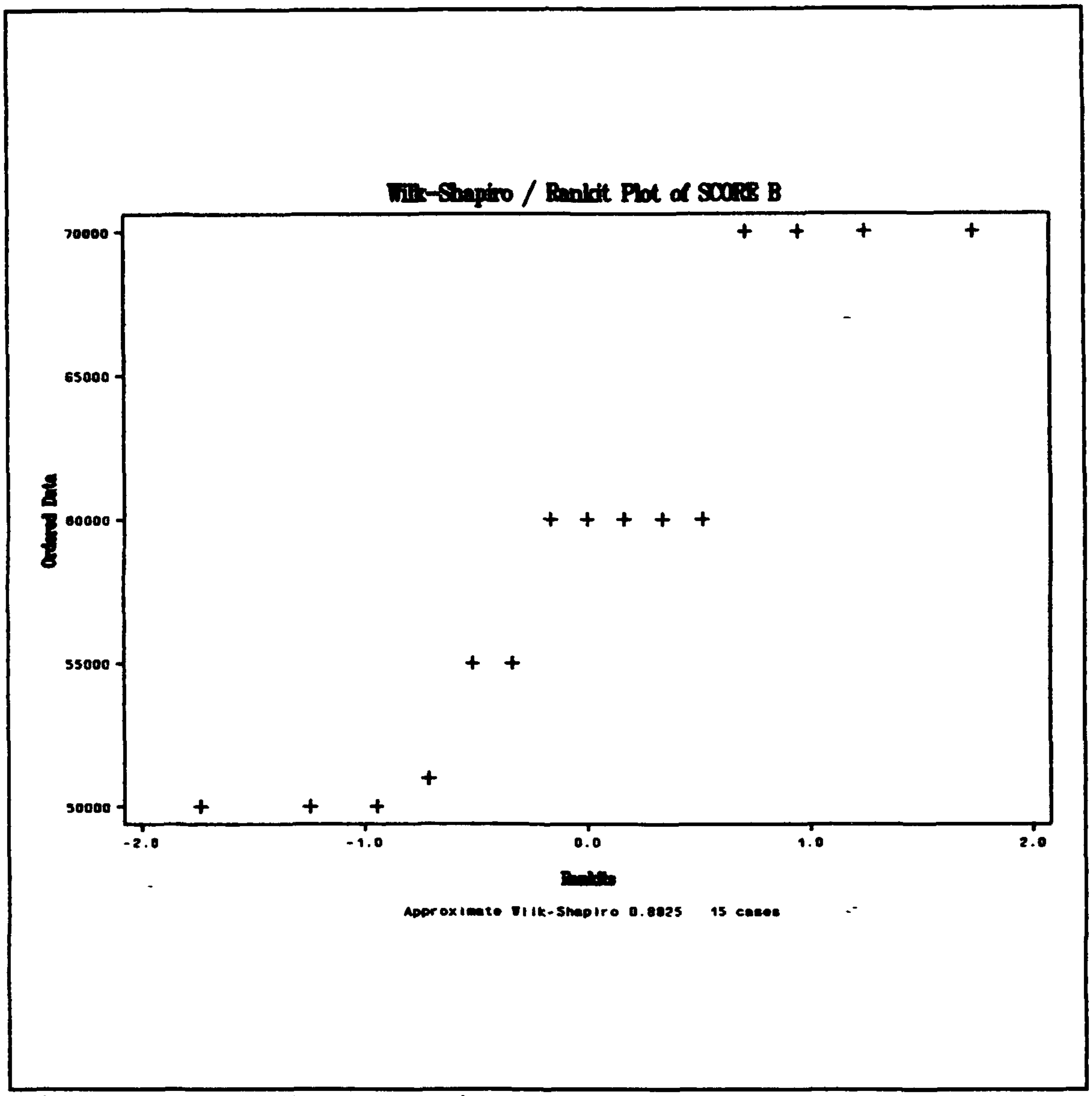

Figure 36. Wilk-Shapiro/Rankit Plot - Company B - Cell 12.

Table 121. Wilk-Shapiro/Rankit Test Statistics For Cells 1 - 12 For Questions 1 - 10.

	Question Number									
Cell Number	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	.7804	.8225	.9149	.5263	.9047	.6333	.8549	.8906	.7099	.8914
2	.8276	.9199	.8389	.5683	.8346	.8544	.8050	.9047	.9573	.9131
3	.7203	.8864	.8698	.7909	.8376	.8309	.8773	.7476	.8452	.7571
4	.5533	.9183	.9253	.5376	.8268	.7326	.5780	.8227	.6533	.6519
5	.7123	.8790	.9307	.7476	.9395	.9236	.6477	.8277	.8873	.8554
6	.7374	.8731	.9441	.5416	.8816	.8933	.5453	.8452	.7476	.7454
7	.7146	.9267	.9462	.5934	.8768	.8868	.7455	.6972	.8398	.7939
8	.7631	.8768	.9421	.7364	.9238	.8681	.7641	.8568	.7610	.8250
9	.7804	.8836	.9100	.5607	.7929	.8895	.7321	.8911	.8894	.7536
10	.7374	.8479	.8868	.3693	.6703	.8696	.7476	.8576	.8894	.8067
11	.7939	.8690	.8409	.7568	.7614	.8961	.7982	.8883	.8783	.7268
12	.7702	.9221	.9676	.4599	.8752	.9218	.6517	.8287	.8287	.8039

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Vita

Captain Robert D. Helgeson was born on September 9, 1964 in Moorehead, Minnesota. He graduated from Saint Thomas Aquinas High School in LaCrosse, Wisconsin in 1983 and attended the University of Minnesota, Minneapolis, Minnesota, graduating with a Bachelor of Science Degree in Management in 1988. Upon graduation, he entered the Air Force and was assigned to the Air Defense Weapons Center Resource Plans Division at Tyndall Air Force Base, Florida. There, as Chief of the Resource Plans Division, he was directly responsible for all wartime planning for the Air Defense Weapons Center until he entered the School of Systems and Logistics, Air Force Institute of Technology, in May of 1992.

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Vita

Captain Robert A. Moriarty was born November 16, 1958 in Boise, Idaho. He graduated from Boise Senior High School in 1977. After high school, he owned his own small business and attended college at Boise State University where he graduated in August of 1985 with a bachelors degree in Business Administration. In February of 1986, he joined the United States Air Force receiving his commission in May of that same year. After commissioning, he completed technical training for the munitions and aircraft maintenance career field. His first assignment was at Holloman Air Force Base, New Mexico where he worked as the Officer in Charge of the 49th Component Repair Squadron's Avionics and Propulsion Branches. He also worked as the Assistant Officer in Charge of the 8th Aircraft Maintenance Unit, 49th Aircraft Generation Squadron. His second assignment, from May 1989 to April 1992, was at Kadena Air Base, Japan where he served as the Officer in Charge of the Flightline Support, Materiel, and Munitions Operations Branches of the 400th Munitions Maintenance Squadron. In May 1992, he was assigned to the Air Force Institute of Technology and began work on his Masters degree in Logistics Management.

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13. ABSTRACT *(Maximum 200 words)*

This study investigated if decision makers could be mislead by computer generated vertical bar graphs that contained varying intensities of fill patterns. It also investigated if the misleading influence of vertical bar graphs caused any differences in interpretation or decision making. A literature review revealed a need to test bar graphs with varying intensities of fill patterns in a controlled environment. By creating vertical bar graphs that use fill patterns, stronger impressions may be produced on the decision maker which may lead to misinterpretations of the underlying data. An experiment was conducted on 182 mid to upper level Department of Defense managers. The experimental group were asked to act as loan evaluators and decide if three fictitious company's should be approved for a loan based on a graphical or tabular presentation of each company's financial data. After reviewing each company's' presentation, the experimental group were then asked to determine a loan amount given specific decision rules. Results showed that differences in interpretation and decision making were created by the trend of the financial data even after data were normalized for the effects of trend. It could not be concluded that fill patterns caused any difference in interpretation or decision making.

14. SUBJECT TERMS

Graphs	Misleading	High-Integrity
Decision Making	Criteria	Cost Analysis

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